Handbook on The Sugar Industry of the Philippine Islands

I.—The Sugar Industry of the Philippine Islands

II.—The Sugar Industry in the Island of Negros

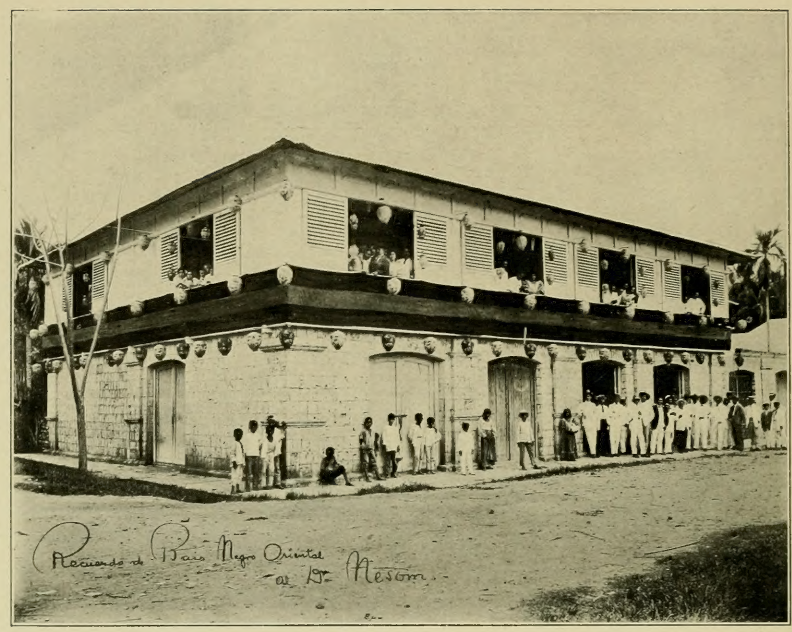

Fig. 1.—THE HOME OF A SUGAR PLANTER, BAIS, ORIENTAL NEGROS.

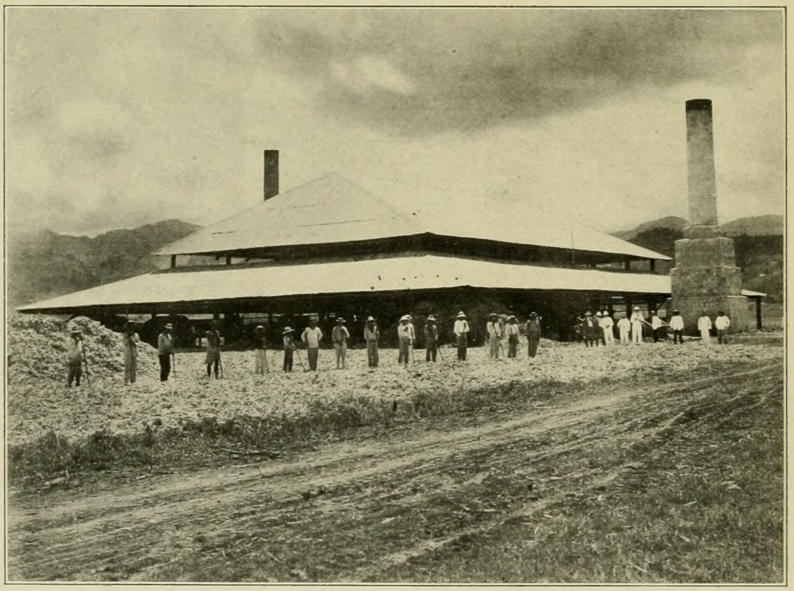

Fig. 2.—THE SAN JOSE MILL, SAN CARLOS, OCCIDENTAL NEGROS.

PLATE I.

DEPARTMENT OF PUBLIC INSTRUCTION
BUREAU OF AGRICULTURE

Handbook on The Sugar Industry of the Philippine Islands

IN TWO PARTS

BY

G. E. NESOM, M. S.
HERBERT S. WALKER
AND THREE COLLABORATORS

PART I. THE SUGAR INDUSTRY OF THE PHILIPPINE ISLANDS

PART II. THE SUGAR INDUSTRY IN THE ISLAND OF NEGROS

MANILA
BUREAU OF PRINTING
1912

Part I

THE SUGAR INDUSTRY OF THE PHILIPPINE ISLANDS

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FOREWORD.

This publication owes its origin to the increasing interest in Philippine sugar both here and elsewhere. A number of causes have combined to keep the sugar industry of the Islands in the same backward condition it was fifteen to twenty years ago. The Bureau of Agriculture has had charge of La Granja Modelo, the old Spanish sugar experiment station in Negros, since 1903, but has been without adequate means or equipment to carry on satisfactory lines of field or mill work. While the political future of the Islands remains uncertain and tariff questions relating to Philippine products imported into the United States continue a subject for debate, the local Government here can not actively encourage the development of the sugar industry along the lines it most deserves.

The Director of Agriculture was ordered to Washington, D. C., in November, 1905, to assist in presenting the arguments in favor of admitting Philippine sugar and other products into the United States free of duty, but the mission failed at that time. The Payne Tariff Bill was passed by Congress in August, 1909, and it was thought would greatly stimulate the sugar industry of these Islands. The Director of Agriculture was on leave in the United States at that time and received instructions to proceed to Louisiana and the Hawaiian Islands to make a brief investigation of sugar growing and manufacturing there. Brief accounts of this trip were published in the Philippine Agricultural Review for May and June, 1910. Plans were made during this trip for issuing a publication on "The Sugar Industry of the Philippine Islands." The Bureau of Agriculture has during several years published a number of general articles on sugar and endeavored through the columns of the Review to keep its readers posted on crop and market conditions.

In the latter part of 1908 the Bureau of Science sent Mr. Herbert S. Walker, a sugar chemist, to the Island of Negros where he spent the entire milling season of 1908–9 studying the sugar industry there. The results of his investigations were published by the Bureau of Science, after the return of the Director of Agriculture from Louisiana and the Hawaiian Islands, in 1910, under the title, "The Sugar Industry in the Island of Negros." It has proven of particular interest as it is the only treatise dealing entirely with sugar which has been

published here since the American occupation. However, it was not readily available to the Spanish speaking people of the Islands, who produce practically all of the sugar grown here. At the suggestion of Don Antonio Roxas, a prominent merchant of Manila, who owns extensive plantations in Batangas Province, the Director of Science recommended that it be translated and published in Spanish. His Excellency the Governor-General directed that the Bureau of Agriculture so publish it. On the recommendation of the Director of Agriculture, the necessary authority was granted for the publication of "A Handbook on the Sugar Industry of the Philippine Islands" to include Mr. Walker's excellent treatise.

The new material prepared for this publication is being issued in English under the title, "The Sugar Industry of the Philippine Islands," and includes a lengthy review of Mr. Walker's work by Austin H. Kirby, B. A., scientific assistant on the staff of the imperial department of agriculture for the West Indies. This will make available the following publications:

"The Sugar Industry of the Philippine Islands" (English). By G. E. Nesom and others.

"The Sugar Industry in the Island of Negros" (English and Spanish). By Herbert S. Walker.

"A Handbook on the Sugar Industry of the Philippine Islands" (English and Spanish). By G. E. Nesom, Herbert S. Walker, and others.

G. E. Nesom,
Director of Agriculture.

Manila, *July, 1911.*

THE SUGAR INDUSTRY OF THE PHILIPPINE ISLANDS.

HISTORIC SKETCH OF THE SUGAR INDUSTRY IN THE PHILIPPINES.

By Harold M. Pitt,

Chairman, Publicity Committee, Manila Merchants' Association.

The history of the sugar industry in the Philippines is slightly obscure but is known to date back more than a century. Its earliest development was probably in the Province of Pampanga, which still ranks second among the sugar-producing provinces. The extensive use there of the two-roller stone type of mills imported from China, and a system of packing the sugar exclusively in earthenware jars (*pilones*), until very recently, tends to show that the Chinese have played an important part in its development.

The first authentic record available to the writer relating to Philippine sugar is from the list of imports into the United States for the year 1795 in which year 134,645 kilos of sugar were credited to these Islands. For the succeeding ten years the importations were not important except that they showed the existence of the industry here. Sailing vessels visiting the Orient during that period often completed their cargos with sugar from Manila and tea from Canton before starting on their return voyages. In those days the supply of sugar came largely from Pampanga Province as the industry in Negros was in its infancy half a century later. An interesting note on the methods employed during the early history of the industry in these Islands has come to light in the record of an ordinance enacted in Pampanga in 1818 prohibiting adulteration, which from this would seem to have been practiced to some extent by sugar growers nearly a century ago.

The most important advance in the sugar industry of the Islands appears to have been coincident with the Crimean war, and was probably due to an increased consumption of sugar throughout the civilized world, which greatly enhanced the price and made the industry very profitable. This condition proved alluring to capital and the increased in-

vestment in the sugar industry of the Philippines quickly followed, resulting in enlarging the plantations and adding to their number in the Provinces of Pampanga, Batangas, and Tarlac, in Luzon, and later in the Islands of Negros, Cebú, and Panay.

The only Spanish records available showing the exports of sugar do not date earlier than 1854, for which year the figures were 47,704 metric tons. Of this amount Negros contributed a trifle over 5,000 tons. Conditions for the cultivation of cane were found to be exceptionally favorable in that island and the production there increased more rapidly than in any other section, jumping from 6,000 tons in 1855 to 30,000 in 1860 and 125,000 tons in 1893. There is a difference among authorities as to the largest production of sugar in any given year. Señor José de Luzuriaga, in an article contributed to the Philippine Census of 1903 gives the crop of 1893 as 300,000 tons and says that this was the largest crop ever harvested up to that time.

Spanish customs records give exports for the year 1892 at 312,798 tons. It is probable, however, that the crops of two years enter into these figures, for the reports of the Manila Chamber of Commerce, compiled by calendar years, credit the heaviest exports to 1893, for which year they are given at 4,186,982 piculs, which is equal to 261,686 tons. There can be no doubt that the year 1893 marked the highest point in the production of sugar in the Philippines.

Immediately following this period a number of causes combined to check development, important among which was the panic and the break in silver that occurred in 18

At that time Russell, Sturgis & Co., a commercial firm founded by Americans with offices in Manila and Iloilo, had grown to be one of the largest institutions of its kind engaged in business in the Orient. Their branch at Iloilo was extensively interested in sugar and had been instrumental, to a considerable degree, in developing the industry in Panay and Negros. It was their custom to make advances to planters for the purchase of machinery and for planting and cultivating the crops, and to take payment in sugar after harvesting. As they were heavy exporters and this system enabled them to control a large proportion of the crop it proved highly profitable, but at the same time made it necessary for them to make very extensive use of their banking credit, as the capital required from one season to another was naturally great. When the panic came it found them with assets that were undoubtedly ample and unquestionably good, but entirely lacking in that very essential liquid quality which permits of ready conversion. Banking facilities were then controlled by British institutions, which, on account of the great stringency then prevailing in the money market, and the resultant failure of the house of Baring Bros. in London, together with the

tremendous drop in the value of silver, then the currency basis of the Islands, were influenced to call in their loans. Russell, Sturgis & Co. were not prepared to meet the demand and were forced into bankruptcy. The planters who had depended upon them for financial assistance were deprived of their support and thus obliged to restrict their operations. The depression in the value of silver placed a heavy burden of exchange on the commerce of the Islands by reducing the market value of all the export products and increasing the cost of foreign goods. The result was clearly evidenced in a falling off in the exports of sugar for 1894 of nearly 70,000 tons, which is equal to 23 per cent of the crop of the previous year.

The Philippine sugar planter, deprived of the financial assistance upon which it had been his custom to rely, was unable to procure the expensive equipment necessary to enable him to produce sugar of the higher grades demanded by the markets and readily obtainable from Cuba, Hawaii, Java, and from the beet-sugar factories of Europe and the United States, and so he was compelled to fall behind in the march of the sugar industry.

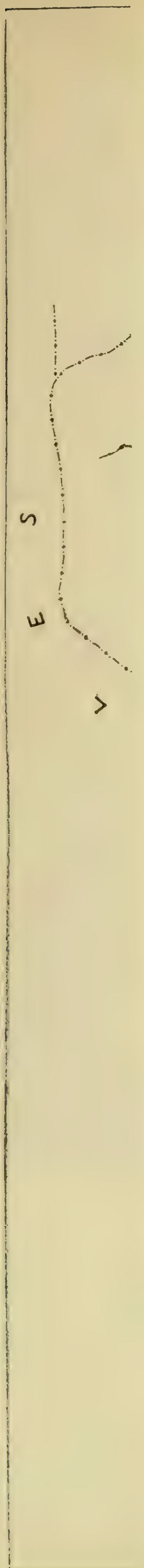
The outbreak of the revolution against Spain in 1896 disrupted conditions pertaining to labor and internal affairs throughout the Islands, and before the country had an opportunity to become tranquillized, the insurrection of 1899 against American authority began and for several years operated to keep the Islands in a stage of ferment that stifled nearly all industrial activity. Then there followed an epizoötic of rinderpest which lasted through two years and killed a large percentage of the work cattle and carabaos on the farms and left the people without the necessary draft animals for tilling the soil. This disease has existed to a greater or less extent in parts of the Philippines for more than twenty years and still persists in limited sections where it continues an occasional danger to all branches of agriculture. It has in past years levied heavy tolls on the sugar planters in the Island of Negros, but about the middle of the year 1910 it was eradicated in the Province of Occidental Negros where one-third of the Philippine sugar crop is produced.

One of the most important factors in keeping the sugar industry in the Philippines from reaching a condition comparable with that in other cane growing countries has been the very antiquated mills and manufacturing facilities available on the plantations. The machinery in use consists mainly of very small three-roller mills driven by animal, steam, or water power, and a battery of open kettles set in a rock furnace and heated by direct firing. There are still in use a few of the native wooden mills and quite a number of the old Chinese stone mills having two vertical rollers with wooden bearings and gearing.

The entire milling equipment of the Philippine sugar industry is of a type dating back at least thirty or forty years as compared with the other tropical sugar-growing countries. Up to the year 1910 there was not a single modern mill nor a piece of vacuum apparatus on a plantation in the Islands. At this writing there are said to be one or two small modern mills in operation, one large one under construction and several others in prospect. These modern mills are the greatest need of the Philippine sugar industry and offer an exceptionally fine field of investment both for the capitalists and the growers who will supply the central mills with cane.

During the Spanish sovereignty of the Philippine Islands the bulk of the crop generally went to the United States, Great Britain, China, and Japan where it was in constant demand. The United States has always been a much larger consumer of Philippine sugar than Spain, which took only a comparatively small part of the crop. Japan has rapidly developed her sugar fields in Formosa and has about ceased buying in the Philippines, but China has continued to take a considerable portion of the lower grade sugars in decreasing quantities up to the present time. The American refineries generally demand grades polarizing 96° or more and will only take the low grade sugars of the Philippines when the better grades are scarce and high priced. The price paid then is usually less than the polarization would indicate the value to be on account of the excessive waste in refining and the increased cost in ocean freight for transporting this extra weight from the Philippines to American ports.

The political event having the greatest effect on the Philippine sugar industry during the American occupation of the Islands was the passage by Congress of the Payne Tariff Bill in August, 1909, under the provisions of which up to 300,000 tons of Philippine sugar are allowed admission free of duty into the United States each year. The previous Act placed the duty on Philippine sugar (and all other Philippine products) at 75 per cent of the regular tariff rate. This last tariff concession has had the effect of greatly increasing both the price of sugar and the amount exported to the United States and has led to a considerable increase in the amount of cane planted; but the limitation to 300,000 tons that may enter duty free acts as a check on the investment of capital in modern mills which are so greatly needed for the proper development of the industry. Under present conditions the grower is able to recover only a part of the sugar content of the cane produced in his fields on account of the very antiquated and inefficient milling facilities at his disposal. Also the quality of the sugar produced is inferior and does not sell readily to the refiners of the United States, on account of the demand there being for the higher grades.




MAP OF
PAMPANGA PROVINCE
SHOWING SUGAR FARMS
PREPARED BY MR. M BRULAY
FOR
THE BUREAU OF AGRICULTURE
1910
SCALE 1:50,000
TARLAC
NUEVA ECIJA
BULACAN
BATAAN
ZAMBALES
Magalang
Angeles
Porac
S. FERNANDO
Arayat
Candaba
Mexico
Sta Rita
Bacolor
Lubao
Masantol
Macabebe
S. Simon
Mabalacat
Floridablanca

PLATE II.

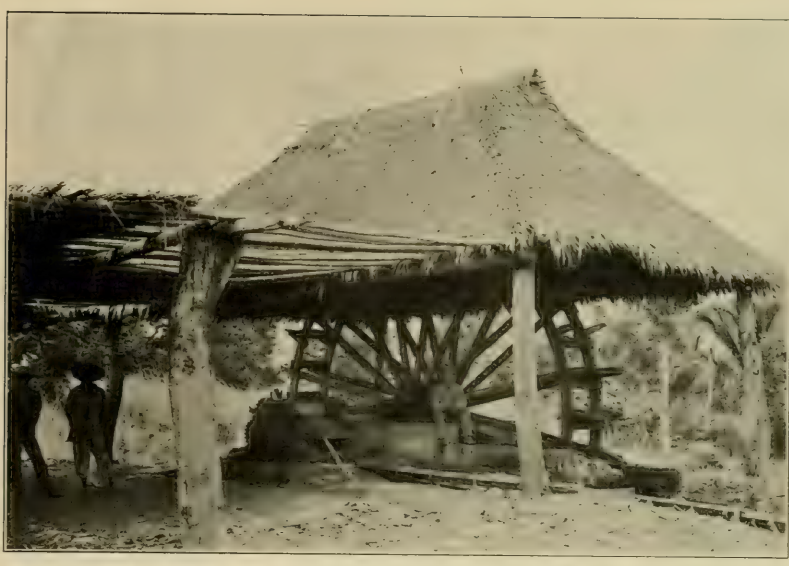


Fig. 1.—SMALL THREE-ROLLER WATER-DRIVEN MILL, MURCIA, TARLAC PROVINCE.

Fig. 2.—PACKING SUGAR TO MARKET ON PONIES, BATANGAS PROVINCE.

PLATE III.

TYPES AND VARIETIES OF CANE.

(1) Common purple, Pampanga Province; (2) transparent or light purple, Rizal Province; (3) dark purple, Laguna Province; (4) very dark purple or Black Manila, Rizal Province; (5) large green bamboo, Bulacan Province; (6) yellowish green or transparent, Rizal Province; (7) white or very light purple, Rizal Province; (8) H. 27—greenish yellow, Honolulu; (9) H. 227—bronze purple, Honolulu.

PLATE IV.

Fig. 1.—FIELD OF LIGHT-GREEN BAMBOO CANE, RIZAL PROVINCE.

Fig. 2.—VARIETY TESTS OF SUGAR CANE WITH VELVET BEANS IN FOREGROUND, SINGALONG EXPERIMENT STATION, MANILA.

PLATE V.

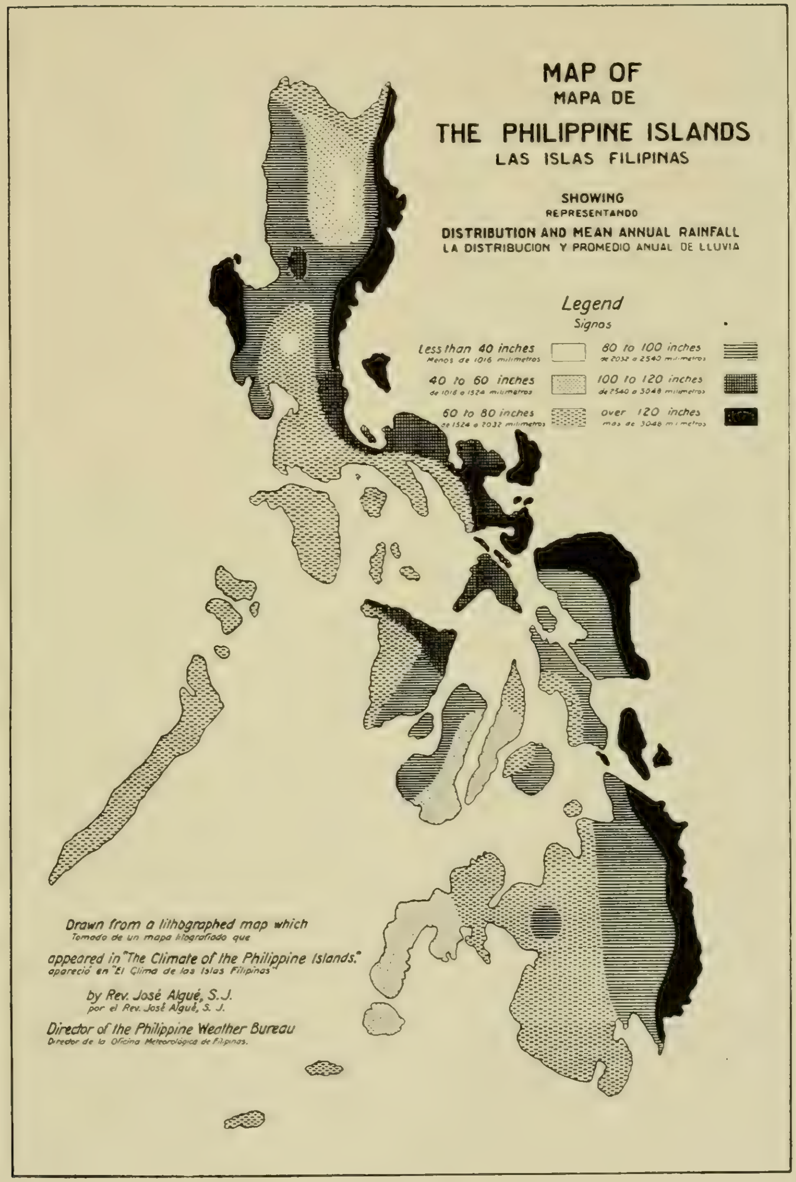

MAP OF
MAPA DE
THE PHILIPPINE ISLANDS
LAS ISLAS FILIPINAS
SHOWING
REPRESENTANDO
DISTRIBUTION AND MEAN ANNUAL RAINFALL
LA DISTRIBUCION Y PROMEDIO ANUAL DE LLUVIA
Legend
Signos
Less than 40 inches
Menos de 1016 milimetros
40 to 60 inches
de 1016 a 1524 milimetros
60 to 80 inches
de 1524 a 2032 milimetros
80 to 100 inches
de 2032 a 2540 milimetros
100 to 120 inches
de 2540 a 3048 milimetros
over 120 inches
mas de 3048 milimetros
Drawn from a lithographed map which
Tomado de un mapa litografiado que
appeared in "The Climate of the Philippine Islands."
apareció en "El Clima de las Islas Filipinas"
by Rev. José Algué, S.J.
por el Rev. José Algué, S. J.
Director of the Philippine Weather Bureau
Director de la Oficina Meteorológica de Filipinas.

PLATE VI.

It is obvious to the reader that for a period extending over nearly twenty years the sugar industry in these Islands has existed in a very precarious state and that it requires a complete reformation if it is to permanently occupy a position of importance among the economic forces of the country. It can be modernized only by persistent effort directed toward improved methods of cultivation and substitution of modern centrals for the present antiquated plantation mills that are so wasteful and inefficient. The time in which this can be accomplished will vary in length with the political influences affecting the Philippines, the readiness with which the investment of capital in this industry can be secured, and the measure in which a thorough spirit of coöperation among the Filipino people may be brought about.

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SUGAR PRODUCTION IN THE PROVINCES OUTSIDE OF NEGROS.

Mr. Herbert S. Walker, in his bulletin, "The Sugar Industry in the Island of Negros," gives a fairly complete description of this industry as it exists in the Provinces of Oriental and Occidental Negros at the present time. His account of sugar growing there is also applicable, in a large measure, to all of the other sections of the Islands. In dealing with the industry in the other provinces it will only be necessary to point out the differences in conditions and methods of sugar production in each section.

THE SUGAR INDUSTRY IN THE PROVINCE OF PAMPANGA.

Pampanga ranks next to Occidental Negros in the production of sugar. During the months of July and August, 1910, a preliminary investigation of the sugar industry of this province was made by Mr. M. Brulay, an assistant agricultural inspector of the Bureau of Agriculture. The main object of this investigation was to obtain statistical information that might serve as a basis for future work in the development of the sugar industry in that province.

Sixteen municipalities, including all of the important sugar-producing territory in the province, were visited by Mr. Brulay. Information was obtained covering the area of land cultivated in sugar cane in each municipality and on each plantation; the production, yield, consumption, and sales of sugar; the methods of milling; and other matters of interest.

These data, in so far as they could be reduced to figures, have been compiled and are included in the following table:

	Municipality.																Total for province.
	Angeles.	Apalit.	Arayat.	Bacolor.	Candaba.	Florida Blanca.	Guagua.	Lubao.	Mabalacat.	Magalang.	Mexico.	Porac.	San Fernando.	San Luis.	San Simon.	Santa Rita.	
Total number of sugar growers in the municipality	29	16	15	22	13	14	9	13	43	29	61	41	71	21	14	5	419
Total area of land actually cultivated in sugar at the present time ..... hectares..	1,424	187	591	751	175	622	200	461	2,476	2,013	2,315	1,339	1,905	243	96	45	14,903
Total area of land actually cultivated in sugar during the year 1909 ... hectares	1,055	120	353	734	135	497	140	190	1,571	1,399	2,220	1,177	1,859	215	78	33	11,776
Total area of land adapted to sugar, but not so planted at the present time.. hectares..	762	271	1,705	745	215	635	124	319	450	1,802	2,110	1,383	1,366	447	255	83	12,672
Total production of sugar for the municipality for the year ending June 30, 1910 ..... piculs	35,870	3,730	10,750	22,350	4,250	16,400	4,030	4,890	61,500	55,320	70,650	35,310	59,570	5,550	2,540	950	393,660
Total estimated production of sugar for the municipality for the year ending June 30, 1910 ..... piculs..	47,670	5,850	19,850	23,050	5,600	20,350	5,900	16,850	71,100	74,350	77,700	39,990	61,610	9,030	3,255	1,300	483,455
Average yield of sugar per hectare piculs..	33	32	35	30	32	31	31	31	30	35	33	30	31	32	33	29	32
Amount of sugar consumed in the municipality, or bartered in the immediate vicinity, during the year ending June 30, 1910 ..... piculs..	619	255	220	560	230	335	180	260	1,375	1,460	1,445	885	1,585	335	225	85	10,054
Amount of sugar sold at wholesale during the year ending June 30, 1910 ....piculs..	33,591	3,475	9,950	21,790	4,170	16,065	3,950	4,640	59,580	53,440	69,595	34,965	55,235	6,715	2,325	865	380.351
Average cost of production .....per picul..	₱4.13	₱4.55	₱3.27	₱4.09	₱4.53	₱4.10	₱4.56	₱4.72	₱3.15	₱2.80	₱3.44	₱4.19	₱4.13	₱4.56	₱4.36	₱4.30	₱4.06
Average amount received .....per picul..	₱8.08	₱8.10	₱7.93	₱7.98	₱7.98	₱8.15	₱8.56	₱8.68	₱7.89	₱7.60	₱8.06	₱8.32	₱8.10	₱8.22	₱8.19	₱8.28	₱8.13
Total number of sugar mills in the municipality	26	17	15	23	11	16	9	15	43	26	64	44	73	20	15	5	422
Average horsepower of the sugar mills in the municipality	13	19	15	12	15	18	16	22	11	14	11	15	10	14	8	13	14

Location.—Pampanga is located just north of Manila in the plain of central Luzon and is the principal province in the Valley of the Rio Grande de Pampanga. This river is navigable for small steamers as far as Arayat. There is a dike on the west bank of the river extending from Apalit to Arayat, a distance of 40 kilometers, and constructed to prevent the flooding of the lands there during the rainy season. The Candaba swamp, a rich alluvial plain on the east side of the river, is still subject to overflow, especially when the Rio Chico in the northern part of the province is flooded. The Parac River and many tidal streams from Manila Bay afford ample means of water transportation for the southern and western part of the province. The Manila Railroad passes through the province and has branches to Florida Blanca, Camp Stotsenburg, and Magalang. The province has fairly good roads between all of the municipalities.

Soil.—The soil of Pampanga Province is principally light, sandy loam with a tendency in many parts to pure sandy soil of great depth. But little fine silt and clay land is devoted to sugar cane. The soils of finer textures generally lie so near the sea level that they are suitable only for rice growing and are devoted to that industry. In general the soils of Pampanga Province are very easy to break and cultivate, but they are subject to drought and deficient in the essential elements of plant food. As no fertilizers are in general use in the growing of sugar cane in this province the resulting crop is very small and many times of an inferior quality.

Cane.—The cane in general use throughout Pampanga is of the purple variety and known as *zebu.* It is reputed to produce a very pure juice, but owing to the very crude methods of manufacturing the quality of sugar made is as a rule poor. As in Negros the number of points planted to a hectare averages between 25,000 and 30,000.

Planting.—The planters seem to entertain the opinion that when cane grows small it can be planted closer together, thereby increasing the tonnage yield. This idea has led to the planting of cane in rows as close as 60 centimeters, and 75 to 90 centimeters may be considered as the prevailing width for cane rows. They also plant it very thick in the drill and before it has reached a height of 1 meter it thoroughly shades the ground. This system of planting has the disadvantage of dwarfing the growth of the cane and makes its cultivation practically impossible without serious injury after the stalks have attained any considerable height. It possesses some advantages, the principal of which are the conservation of moisture, destroying grass and weeds, and rendering further cultivation unnecessary.

Ratoons.—It is a common custom to abandon the stubble after harvesting the crop of plant cane and either allow the land to lie fallow for one year or plant it in corn or some other crop. The few

who have attempted ratooning secured such light yields that it is doubtful whether this system is profitable.

Yield.—Yields of 8 tons per hectare have been produced in Pampanga and the present average of but little over 2 tons is far below what it would be if improved methods were used.

The Spanish Government maintained an experiment station at Magalang on the north slope of Mount Arayat. Here they had a small sugar mill and did some experimental work with cane. D. Manuel Soto, the director of this station, undertook in 1895 and 1896 to show the value of applying lime and using irrigation on eight plots with the following results:[1]

Number of plot.	Cane.	Juice.	Percentage of sugar recovered.	Sugar manufactured.	Bagasse.	Percentage of bagasse in total cane.
	Kilos.	*Kilos.*		*Kilos.*	*Kilos,*	
1	33,566	20,241	7.65	2,550.00	13,325	39.79
3	33,866	20,483	7.70	2,608.00	13,383	39.51
5	34,033	20,667	7.80	2 650.00	13,366	39.27
7	34,100	20,758	7.90	2,691.66	13,342	39.12
2	33,666	20,316	7.60	2,558.33	13,350	39.70
4	33,900	20,558	7.65	2,591.66	13,342	39.35
6	34,033	20,717	7.70	2,616.66	13,316	39.12
8	34,033	20,742	7.80	2,650.00	13,291	39.05

Mills.—With only two exceptions the mills of the province are very small in size, have only three rollers and are propelled by animal power or small steam engines.

The evaporating apparatus consists of a series of cast-iron kettles set in a furnace and fired with the cane trash which is taken from the mill, placed in the sun to dry and returned to the furnace room for fuel. It is never sufficient in quantity for firing the steam boiler and evaporating kettles. The mill is generally run independently and wood is used as fuel for the boiler at considerable expense, averaging as much as ₱3.20 per ton.

After the juice has been evaporated down to a thick, heavy mass, it is poured into a large earthenware jar (*pilon*), holding about an average of 63.25 kilos (1 picul or 137½ Spanish pounds) of sugar. These are then set in wooden troughs so that the molasses contained in the sugar will drip through the hole in the bottom of the *pilon* and run into a vessel placed at the end of the trough. For the best grades of sugar, the dripping is continued during a period of several months and sometimes is hastened by applying a thin layer of clay on top of the sugar and pouring water over this so that it slowly percolates through the clay

[1] Boletin oficial Agrícola de Filipinas, Tomo III, p. 129.

and down through the sugar, thus producing a washing effect on the crystals. The sugar is a hard mass resembling rock salt, the top is generally stained and the bottom still contains molasses and sediment. They are removed as low grade products while the central portion is broken into irregular pieces for sale to shop-keepers and into small, cubical blocks for sale direct to users. The bulk of Pampanga sugar has always been used in the local market by Chinese for the purpose of making *caramelo,* a sort of spongy candy clarified with white of eggs and used almost exclusively by the Filipinos for table purposes.

Since the American occupation there has been a tendency to use more and more refined sugar and many of the Pampanga growers are now producing the mat sugars, which are shipped in palm-leaf bags the same as that from Iloilo, which contains all of the molasses and other impurities just as it comes from the caldron.

SUGAR PRODUCTION IN THE OTHER PROVINCES.

Batangas.—As shown in the crop statistics for the fiscal year 1910, Batangas Province ranks third in the tonnage of sugar produced. The soil of this province differs considerably from both Negros and Pampanga, being generally undulating, consisting of rather heavy red or yellow clay. In the vicinity of Lake Taal there is considerable black volcanic soil made up of decomposed lava. The cane fields are generally small and widely separated. The type of cane grown, the implements, agricultural methods, and mills are the same as for Pampanga. The possibilities for sugar growing in this province are indicated by the heavier yield than that of the provinces having sandy soil like those in central Luzon, north of Manila.

Iloilo ranks fourth in the amount of sugar produced. This province consists mainly of rice lands, lying north of Iloilo with occasional small fields of sugar on the elevated portions. Along the foothills on the east and west sides of the province and along the Philippine Railway in the vicinity of Passi in the northern portion of the province considerable cane is grown. Iloilo is a well-cultivated province in which the sugar industry was developed many years ago and the small amount produced there at the present time is due rather to the demand for the land for the purpose of growing rice than from any other cause. The yield per hectare is greater than the average for Occidental Negros. The land is of rather heavy texture and contains considerable limestone in the foothill districts.

Tarlac Province ranks fifth as a sugar producer. The conditions in this province are almost identical with those of Pampanga, except that the soil is even more sandy and subject to drought. The effect of this is shown in a smaller yield per hectare.

Ilocos Sur is sixth among the sugar producing provinces and reports the 1910 crop at 6,396 tons. This province has a fairly good clay soil with some sand near the seashore and along the rivers. There is also some coral soil in this province.

All of the other provinces, as shown in the crop report for 1910, produce less than 5,000 tons and need not be given special mention in this publication. This does not mean that they are not capable of producing sugar, but that the industry is simply not developed there at the present time. Mindoro is in the class of provinces producing less than 100 tons, but a plantation of about 22,000 hectares is now being put into cultivation in that island and will have one of the largest and most modern mills in the world. There are many other sections in the Islands in which the industry may be developed in the future.

THE MODERN CANE SUGAR INDUSTRY.

SUGAR CANE.

Nature and origin.—Sugar cane (*Saccharum officinarum*) belongs to the same natural order of plants as the grasses, which it closely resembles except being of giant proportions. There are both wild and cultivated species of cane widely distributed throughout the tropical and subtropical regions.

All of the valuable cultivated species and varieties originated in the South Pacific Islands. They show many variations in color, size, height, and composition.

Parts of plant.—The cane plant is divided into roots, rootstock, stem, leaf, and flower. The roots are small and fibrous, like those of the grasses, and spring from the nodes of the rootstock and stem, spreading out laterally in all directions in the cultivated soil around the plant. But few of them go deeper than the land has been plowed, except in very porous or dry soils, but 1 meter may be considered as the extreme length of the roots and the greatest depth to which they will penetrate the soil under average conditions.

The stem or stalk is cylindrical in form and is made up of a series of joints or nodes and internodes. In diameter it varies from about 2 to 7 centimeters and in height from 1 to 6 meters. The color of the stalk varies from a light green to a dark purple and in a general way the lighter colored varieties with the long internodes are much softer and easier to mill than the dark colored woody varieties. They have less fiber and rind in proportion to weight of cane, contain a larger percentage of sugar, and the juice is of higher purity than the slow-growing dark purple, yellow, and black canes.

The leaves are produced from the modes and consist of a sheath and blade. The sheath embraces the internode, covers the eyes and is lighter in color than the blade which is continuous with the sheath, averages about 1 meter in length and 5 to 8 centimeters in width. The leaves of most canes are green in color, though in some varieties they are purple or white.

The flower or "plume" of cultivated sugar cane appears after the plant has reached maturity and usually at some definite time of the year, which varies with the different cane-growing countries. As the seeds are very delicate and only a few of them fertile, they are not generally considered a practical means of propagating cane. They have been successfully germinated by experiment stations and botanic gar-

dens, but nearly every seed produces a different type of cane and the use of seeds has resulted in originating many new varieties, such as D. 74, B. 147 and H. 20.

The varieties of cane.—In the earlier history of the cane-sugar industry the means of communication between the countries producing this crop were poor and there was but little systematic knowledge of the cane plant. Sugar was among the products shipped during the earlier development of overseas commerce. In almost every country where sugar was grown there were different kinds of cane, and many of these were taken from one country to another by vessels carrying sugar, often without obtaining any information as to the name, characteristics, or value of the cane. Naturally those varieties having a good reputation as sugar producers were most frequently taken to other places, but the history of the cane in its new home was often lost. For these reasons the reed-like varieties of India and the elephant canes of Cochin-China were spread to only a limited extent, while that from the Island of Otaheite was taken to most of the countries where sugar is grown. It was generally given the name of the country or place to which it was taken, and the place of its origin soon forgotten. When introduced into the Hawaiian group it was first grown at Lahaina plantation on the Island of Maui and has ever since been known throughout the Hawaiian Islands as Lahaina cane. In other countries to which it has been taken it is known as Bourbon, Singapore, Cuban, and by many other names.

Philippine varieties.—According to the classification given by Deerr[1] there are cultivated in the Philippines at least four varieties of cane. One of these is a small white cane of the Salangore type, grown to only a limited extent, mostly around Laguna de Bay. In the vicinity of Manila and other places where there is a demand for a long-jointed, soft cane, suitable for chewing, a limited amount of a light green cane is grown. This is no doubt an Otaheite bamboo variety. A very dark purple or black cane, having a hard rind and dense fibrous structure, is grown to a limited extent in Negros and some other parts of the Visayan Islands, where it is said to be a very poor yielder of sugar and hard to mill. It is probably one of the Tanna canes mentioned by Deerr under the name of "black Manila."

The great bulk of the sugar crop of the Islands is produced from a purple variety[2] known by the Spanish name "caña morada," which is evidently a purple bamboo Cheribon cane.

In addition to these the Bureau of Agriculture has introduced into the Islands Louisiana striped, rose bamboo, Lahaina, D. 74, H. 16, H. 20, H. 27, H. 69, H. 227, and H. 309.

Adaptability to climate.—In a general way sugar canes are the product of the climate in which they grow and when changed from

[1] Noel Deerr's Cane Sugar.

[2] Herbert D. Walker's The Sugar Industry in the Island of Negros.

one location to another adapt themselves to new surroundings. The tropical varieties generally have a growing period of one year or more while the subtropical varieties reach maturity in from eight to ten months.

In tropical countries where the wet and dry seasons are well marked there is a tendency for sugar cane to adopt an early maturing habit. The common purple variety (caña morada), which produces the bulk of the crop grown in the Philippines, is often harvested in from eight to ten months after planting, but does not reach maturity in less than eleven or twelve months.

In the higher altitudes where the range of temperature is low at night cane tends to grow during a much longer period before reaching maturity.

A considerable area of yellow Caledonia cane grown in the Hawaiian Islands at an altitude of 300 to 600 meters grows for a period of eighteen to twenty-four months before being harvested. Such cane generally contains a high percentage of fiber and a low percentage of sugar.

The color of sugar cane also varies with the climate in which it is grown, the tendency being toward light colors in the tropics and darker colors in the subtropical and temperate regions. Some types of cane are much more susceptible to changes of environment than others, and readily change in form, color, and composition.

The effect of variety on yield.—The older types of sugar cane grown in a given country generally run very uniform in tonnage yield and content of sugar, or total tonnage of sugar produced.

The ideal cane is the one producing the largest amount of sugar on a given area, and the two factors most important in heavy sugar production are large tonnage yield of cane containing a high percentage of sugar. Nearly all of the experiment stations doing special work in sugar are endeavoring to produce by selection and by the propagation of seedling varieties ideal types of cane for the conditions prevailing in the country where the work is done. The seedling variety D. 74, produced in Demerara, South America, proved to be a short seasoned cane of but little value in that country, but particularly well suited to the conditions in Louisiana. The Hawaiian sugar planters' experiment station at Honolulu has originated a number of varieties, among which may be mentioned H. 20, which promises to be an exceptionally fine cane for the Hawaiian Islands. It, however, has a serious drawback in the fact that it does not produce eyes on the upper portion of the stalk, thus making it impossible to propagate this cane by points. This would necessitate cutting a supply of young body cane sufficient for seed each year before it reached maturity, as the eyes on the main stalk lose their vitality by maturity.

In a preliminary test made in the Hawaiian Islands the seedling

variety H. 27 gave a yield of 34.5 metric tons and H. 227 a yield of 37.5 metric tons of sugar per hectare, as compared with a yield from yellow Caledonia of 27.3 metric tons and Lahaina of 24.2 metric tons under similar conditions. But even with this excellent showing it would not be advisable to plant large areas of these or any other new canes until they have been thoroughly tested in small plantings.

Composition.—Deerr gives the limits of the composition[1] of cane as follows:

	Percentage.
Water	69 –75
Saccharose	7 –20
Reducing sugars	0 – 2
Fibre	8 –16
Ash	.3– .8
Organic non-sugar	5 – 1.0

The principal factors causing variation in the composition of cane are climate, soil, rainfall (or irrigation), variety, time of planting, cultivation, and time of harvest. It is also influenced by the cane blowing down so that the stalk sends out roots, by scorching from fires passing through the field and from cutting too long before milling. In the temperate climate of Louisiana cane contains less sugar and generally less fiber than in tropical countries like the Philippines.

The following table shows the average content of sugar and fiber in cane and the purity of cane juice in three tropical countries:

	Sugar.	Fiber.	Purity.
	Per cent.	*Per cent.*	*Per cent.*
Java[a]	12.42	11.48	85.00
Hawaii[a]	14.03	12.37	93.55
Philippines[b]	16.06	10.02	90.38

[a] Proceedings Twenty-eighth Annual Meeting of the Hawaiian Sugar Planters' Association.
[b] Walker's The Sugar Industry in the Island of Negros.

The principal value of cane is in the sugar it contains, though the fuel value of bagasse varies directly with the fiber content.

The purity of cane juice is the percentage of sugar in the total solids it contains. The purity given above for Java and Hawaii are for clarified juice, while that for the Philippines appears not to have been clarified.

In Pampanga and other sandy-land districts cane at any age shows a tendency to a higher purity of juice and the grade of sugar manufactured by the local methods used here is always higher than in districts of rich lands. The harvesting of immature cane resulting from a short growing period, from being grown at high altitudes on sod lands and of the long growing varieties like the yellow Caledonia,

[1] Deerr's Cane Sugar, page 13.

always produces a juice of low purity, out of which it is impossible to make good sugar by the milling methods commonly used in the Philippines.

CLIMATE AND SOIL.

Range of climate.—"Sugar cane is essentially a tropical plant but under certain favorable conditions is successfully cultivated in subtropical districts." [1]

The Hawaiian Islands, Cuba, Java, and the Philippines are typical sugar countries within the tropics and furnish a large part of the world's supply. Sugar is grown in Spain as far as 37° north and in New Zealand down as far as 37° south. The center of the Louisiana sugar district is in 30° north, while in Argentina the bulk of sugar is grown between 22° and 25° south. It is generally believed that sugar cane grows best near the seacoast in warm, humid climates, although there is much evidence to show that periodic dry spells with irrigation afford a very favorable condition for its growth. The sea breezes are thought to benefit the cane by being laden with moisture carrying a small amount of salt spray. Land breezes, particularly those passing over dry, hot countries, are injurious to the growth of cane by evaporating the moisture from the soil. The leaves do not resist hard winds and are readily injured and the stalks are often blown down by even light storms, particularly when the ground is wet so that the roots fail to support the great weight of the stalks. In level countries, subject to hard winds, frequent rows of trees having dense foliage should be planted to form windbreaks.

On the Ewa plantation, on the southern coast of the Island of Oahu where it is comparatively dry and irrigation is supplied from artesian wells, the largest sugar yields of the world have been produced. It is a well-known fact that in the Philippine Islands sugar cane does not suffer serious injury during moderate dry spells, especially when planted on the heavier types of soils which resist the evaporation of moisture. During the growing period it flourishes best when there is a constant high temperature and the development of the cane is generally in direct proportion to the total heat which it receives while growing. Low temperatures tend to produce small stalks with short joints and consequent low tonnage yield. The maximum production can only be secured under tropical suns. A cool season greatly favors maturity and high purity of the juice in the cane if it occurs after a normal period of growth. In the Philippines this cool season is not well marked but generally occurs in most parts of the Islands in midwinter, soon after the close of the rainy season.

Rainfall and irrigation.—The ideal conditions of water for growing

[1] Deerr's Cane Sugar, page 18.

cane are found in countries where the normal rainfall is constant throughout the year, except possibly during the milling season after the cane has reached maturity and where irrigation is unnecessary. As the rainfall varies very widely in the different cane-producing countries of the world no particular standard as to the amount of rain required can be given. Doctor Stubbs states that in Louisiana a rainfall of 1,524 millimeters (60 inches) gives the best results, especially when as much as 1,143 millimeters (45 inches) of this falls during the growing season of the cane. The rainfall of the Hawaiian Islands is very irregular and varies in sections where cane is successfully grown, from 500 to 10,000 millimeters (20 to 400 inches).

Rev. Miguel Saderra Maso, of the Philippine Weather Bureau, has compiled the following table showing the average annual, and mean monthly rainfall at the principal observation stations in the Islands (see page opposite).

As can be seen the average annual rainfall in most parts of the Philippines is sufficient to produce a good crop of cane without irrigation, but there is a distinct dry spell in many provinces during the first three or four months of the year. Maxwell[1] gives the amount of rainfall required to mature a crop of sugar cane growing for a period of seventeen months as 2,540 millimeters (100 inches), an average of about 150 millimeters (6 inches) per month or a total of 1,800 millimeters (72 inches) per annum. He also says that the best results are obtained when the young cane receives only about 52 millimeters (2 inches) per month, while the cane in full vigor should receive monthly about 305 millimeters (12 inches) per month. The latter figures are amply borne out by extensive observations on irrigation in the Hawaiian Islands where there is a tendency to apply too much water to the young cane.

The total rainfall of the best sugar districts in the Philippines is slightly in excess of the amount required according to Maxwell and is almost ideal in distribution, which permits of dry-season planting and cultivation from January to May with abundant rainfall for the main growing period from June to December. The Government irrigation projects planned for the Philippines will have only a limited use in sugar growing though irrigation will prove very valuable to sugar growers in those sections in which the average monthly rainfall of the dry season is below 50 millimeters.

Sugar-cane soils.—The principal characteristic of good sugar soil is its ability to retain a high percentage of moisture. Dr. W. C. Stubbs says that the best soil for sugar cane should be capable of holding 25 per cent of its weight of moisture. This quality is only found in the

[1] Bulletin No. 90, Office of Experiment Stations, U. S. Department of Agriculture.

Mean monthly rainfall, in millimeters, at important stations.

Province.	Station.	Average annual rainfall.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Number of years.
Cagayan, Luzon	Aparri	2,135	247	95	45	37	94	129	145	233	303	308	277	218	11
	Tuguegarao	1,572	17	8	26	36	79	171	134	128	238	295	3[illegible]3	103	6
Ilocos Sur, Luzon	Vigan	2,134	3	1	3	12	73	315	556	474	483	154	57	4	14
Nueva Vizcaya, Luzon	Bayombong	1,186	31	9	37	70	154	77	153	124	178	132	107	77	8
Union, Luzon	San Fernando	2,266	12	2	4	10	160	362	526	609	387	121	63	6	5
Benguet, Luzon	Baguio	4,001	33	6	21	113	479	549	784	832	658	367	132	21	5
Pangasinan, Luzon	Dagupan	2,141	7	14	17	57	317	439	534	391	408	159	80	13	5
Tarlac, Luzon	Tarlac	1,901	4	8	33	73	172	268	395	258	377	207	67	35	5
Nueva Ecija, Luzon	San Isidro	1,784	17	4	14	24	201	217	341	278	360	179	88	55	15
Pampanga, Luzon	Arayat	1,690	17	5	8	36	149	259	373	212	307	223	59	38	5
Zambales, Luzon	Masinloc	3,954	8	0	5	85	125	1,135	992	758	518	247	63	20	3
Bulacan, Luzon	Marilao	2,103	11	6	8	48	154	360	545	372	280	183	59	73	4
Rizal, Luzon	Manila	1,926	28	10	17	31	103	249	388	350	368	190	131	58	41
Laguna, Luzon	Biñang	1,298	7	18	0	9	62	294	280	125	148	132	46	175	2
Tayabas, Luzon	Tayabas	1,449	135	42	60	23	99	83	96	73	116	239	283	195	6
Camarines, Luzon	Nueva Caceres	1,818	106	57	54	120	76	178	194	155	268	199	225	183	7
Albay, Luzon	Albay	2,960	233	168	229	155	188	207	266	242	299	212	301	457	6
Sorsogon, Luzon	Gubat	2,908	293	191	114	100	138	114	130	99	270	341	540	572	3
Masbate	Palanoc	1,445	192	87	30	48	75	120	127	129	284	130	163	57	3
Samar	Catbalogan	1,955	256	210	33	128	99	129	85	182	256	218	200	155	2
Leyte	Taclo an	2,170	213	143	76	138	178	238	110	213	184	171	254	250	3
	Ormoc	2,258	229	75	82	78	80	196	290	290	334	266	185	147	5
Capiz, Panay	Capiz	2,859	201	118	13	62	189	410	451	383	398	835	348	446	5
Iloilo, Panay	Iloilo	2,188	50	20	25	51	172	209	549	327	280	261	135	115	9
Antique, Panay	San Jose de Buenavista	2,378	26	0	4	60	114	324	571	360	459	308	94	54	4
Occidental Negros	Bacolod	2,160	86	48	10	29	117	234	379	329	281	175	139	228	5
	La Carlota	2,591	59	55	47	87	229	304	358	378	392	350	199	127	9
Cebu	Tuburan	1,395	113	78	18	12	69	123	171	121	175	197	161	153	5
	Cebu	1,489	110	43	60	31	99	180	173	148	176	181	123	160	11
Bohol	Tag ilaran	2,480	109	109	48	393	180	173	416	117	176	383	196	175	5
Surigao, Mindanao	Surigao	2,637	289	280	189	305	176	55	145	77	145	222	332	416	5
Agusan, Mindanao	Butuan	1,998	235	115	98	67	193	146	123	73	145	166	307	326	4
Misamis, Mindanao	Balingasag	1,724	70	57	3	27	47	229	239	169	314	225	253	86	4
	Cotabato	2,140	16	99	145	195	224	297	250	213	252	233	117	117	4
	Davao	2,026	156	110	118	170	195	209	246	202	149	191	128	146	7
	Zamboanga	905	25	38	25	42	88	109	112	80	83	96	125	77	6

heavier types of clay, silt, and alluvial soils, particularly when they contain a liberal amount of humus. The soils must, however, not be so located that they can not be thoroughly drained, as good crops can not be produced where stagnant water is present in the soil. Soils of a lighter character will produce good crops of cane when supplied with abundant humus and fertilizer if there is liberal and constant rainfall or irrigation is provided. There is no doubt that the best type of soil for growing cane in the Philippines occurs in the Province of Occidental Negros and in isolated places in Oriental Negros, as described by Mr. Herbert S. Walker in his bulletin, "The Sugar Industry in the Island of Negros." There are also excellent sugar soils in limited amounts throughout the Islands, particularly the black volcanic lands around Laguna de Bay, the red clay lands of Batangas Province, and the dark clay loam soils of Mindanao. The sandy level land of the Province of Pampanga is a very poor type of sugar soil, especially in view of the fact that the growers there use neither fertilizers, irrigation, nor modern methods of culture. Below are given sample analyses by the Bureau of Science of soils taken in several parts of the Islands outside of Negros.

Chemical analyses.

		Moisture.	Volatile matter.	Potash (K_2O).	(Na_2O).	Lime (CaO).	Phosphoric acid (P_2O_5).	Nitrogen.
	San Francisco de Malabon:							
1	First class	8.79	11 48	0.15	0.52	0.71	0.07	0.11
2	Second class	4.98	8.06	.19	.25	.36	.03	.14
3	Buena Vista	8.46	11.12	.19	.34	.53	.09	.07
	Imus, Cavite:							
4	First class	8.73	11.79	.18	.29	.48	.10	.14
5	Second class	8.73	10.90	.12	.16	.87	.11	.10
6	Dasmariñas, Cavite	9.68	11.00	.18	.81	.51	.11	.10
7	Singalong, Manila	2.61	3.45			1.713	.056	.073
8	Biñan, Laguna		7.34	.22		.46	.05	.15
9	Balasan, Panay:							
	Surface soil	4.34	6.76	.14		.82	.05	.199
	Subsoil	4.24	5.84	.11		.39	.05	.203
10	Calamba Estate:							
	Surface soil	9.785	11.705	.345		.905	.164	.296
	Subsoil	13.03	11.17	.33		.785	.143	.243
11	San Fernando, Pampanga:							
	Surface soil	4.91	6.39	.443		1.02	.467	.106
	Subsoil	6.59	6.60	.194		1.13	.362	.075
12	Stotsenburg, Pampanga:							
	Surface soil	3.20	6.25	.063		.10	.113	.111
	Subsoil	4.14	6.33	.060		.23	.134	.077
13	Magalong, Pampanga:							
	Surface soil	1.25	3.96	.095		.55	.127	.073
	Subsoil	.78	1.77	.112		.50	.126	.054
14	San Miguel, Tarlac:							
	Surface soil	2.08	3.38	.095		.42	.038	.095
	Subsoil	2.71	3.53	.043		.39	.038	.054

Mechanical analyses.

		Coarse sand (1.0 to 0.5 mm.).	Medium sand (0.5 to 0.25 mm.).	Fine sand (0.25 to 0.1 mm.).	Very fine sand (0.1 to 0.05 mm.).	Silt (0.05 to 0.005 mm.).	Clay (less than 0.005 mm.).
9	Balasan, Panay:						
	Surface soil	2.63	12.06	17.71	20.11	23.33	24.33
	Subsoil	1.59	9.56	17.20	20.25	30.72	21.11
10	Calamba Estate:						
	Surface soil	1.05	2.50	5.58	5.62	43.98	41.035
	Subsoil	1.14	3.295	3.94	5.525	44.42	41.955

No. 1: Rice soil, classed as first class in the San Francisco de Malabon Estate. A sticky and tenacious black clay. Sample from one of best producing fields near San Francisco de Malabon, Cavite.

No. 2: San Francisco de Malabon soil, classed as second class. Shallow rock found at 5 inches from surface. A lighter clay than No. 1. Does not produce well.

No. 3: Sugar-cane soil from Buena Vista. A loam; high land and unirrigated, but produces a fair crop of cane. Located on San Francisco de Malabon Estate.

No. 4: First-class rice soil from Imus, Cavite. A heavy, black, sticky clay. Produces good crops.

No. 5: Second-class soil from Imus, Cavite. Lighter than No. 4. Lower producing capacity, due chiefly to insufficient water supply.

No. 6: Sugar-cane soil from Dasmariñas, Cavite. A loam; high land, unirrigated. Produces good crops.

No. 7: Six samples (3 of surface soil and 3 of subsoil) from Singalong experiment station.

No. 8: Soil from Biñan, Laguna. Calculations based on sample dried at 100° C.

No. 9: Sugar-cane soil from near Balasan, Panay.

No. 10: Average of analyses of two samples of soils from the Calamba Estate. The surface soil is a very dark, brown loamy clay, having an average depth of 50 centimeters, while the subsoil is a reddish yellow clay.

No. 11: Surface soil to depth of 25 centimeters from fields of sugar cane near San Fernando, Pampanga; a dark loam 20 to 25 centimeters in depth underlaid by a yellow clay subsoil which, at about 1 meter from the surface, grades into a fine yellow sand.

Subsoil (25 to 50 centimeters) from soil type described above.

No. 12: Surface soil from foot hills near Camp Stotsenburg, Pampanga. This is a dark loam, abundantly supplied with organic matter to a depth of 20 to 25 centimeters, underlaid by a deep, yellowish clay subsoil.

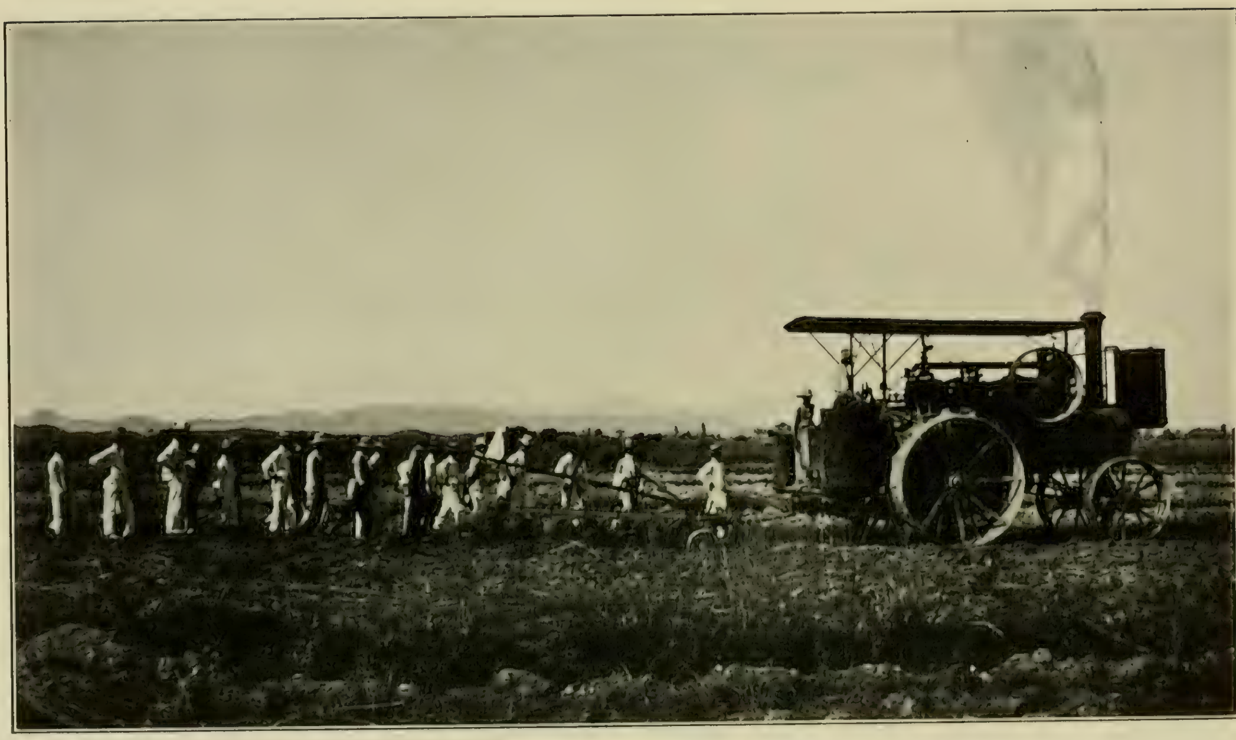
No. 13: Surface soil from sugar lands near Magalang, Pampanga. It is very sandy to a depth of at least several meters, and hence is well drained. The surface 30 centimeters of soil is well supplied with organic matter, being nearly black in color.

Subsoil of No. 13: This subsoil consists of a light colored sand, coarser than the surface soil just described, but otherwise the only apparent difference between the two is the organic-matter content.

No. 14: Surface soil from the Tabacalera Estate, San Miguel, Tarlac. Description much the same as for No. 13, except that No. 14 contains more fine soil particles and less coarse sand.

BREAKING LAND WITH GANG PLOW, TARLAC PROVINCE.

PLATE VII.



BREAKING LAND WITH STEAM TRACTION ENGINE, TARLAC PROVINCE.

PLATE VIII.

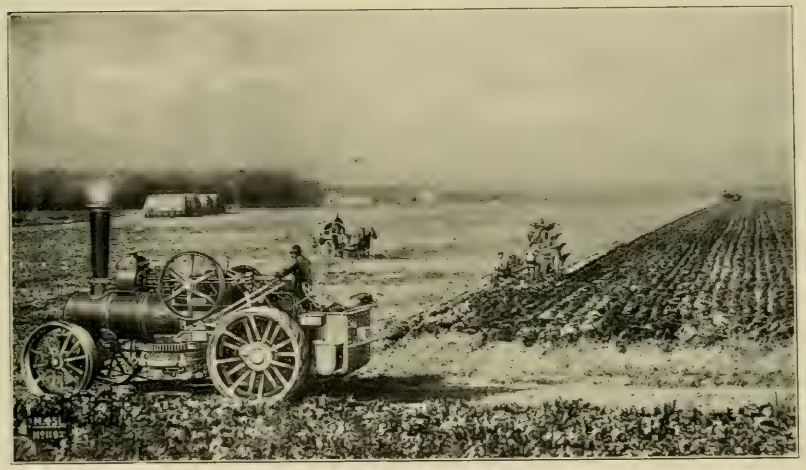


Fig. 1.—DOUBLE-ENGINE SYSTEM OF STEAM CABLE PLOWING. (Fowler.)

Fig. 2.—STEAM CABLE PLOW AT WORK, SAN CARLOS, OCCIDENTAL NEGROS.

PLATE IX.

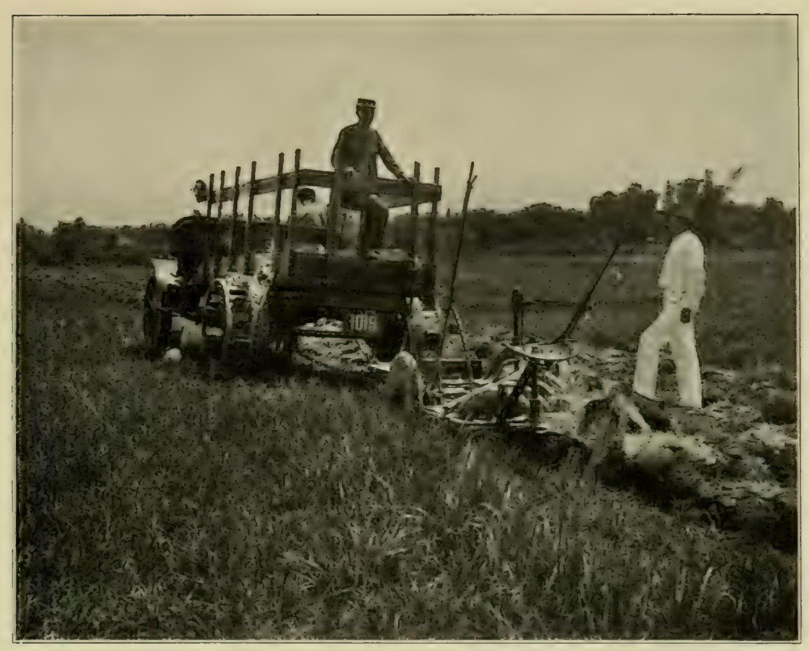


Fig. 1.—GASOLINE FARM TRUCK PULLING DISK GANG PLOW. (Avery.)

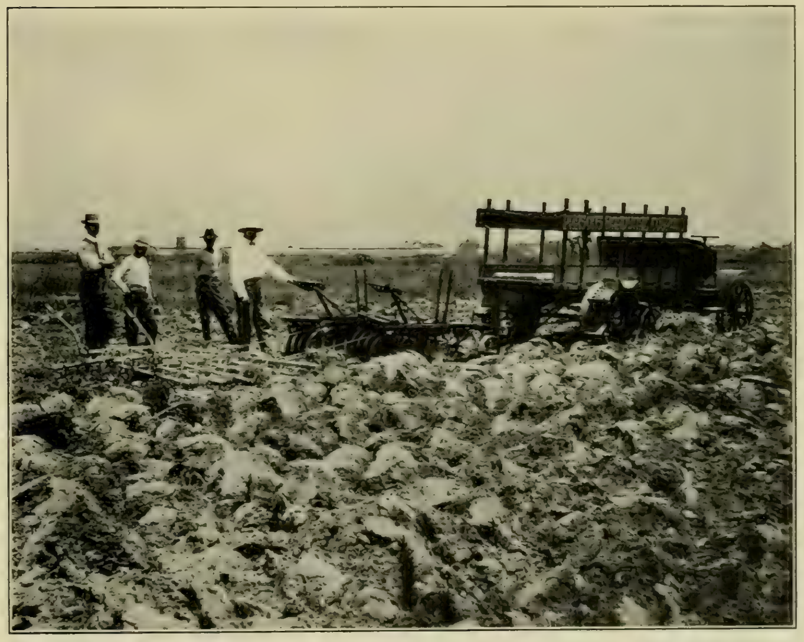


Fig. 2.—GASOLINE FARM TRUCK PULLING COMBINATION OF DISK AND SMOOTHING HARROWS. (Avery.)

PLATE X.

Fig. 1.—FURROWING OUT ROWS AND PLANTING CANE POINTS, OCCIDENTAL NEGROS.

Fig. 2.—YOUNG CANE AT BEGINNING OF RAINY SEASON, OCCIDENTAL NEGROS.

PLATE XI.

Subsoil of No. 14: Soil particles larger than those of surface soil. This subsoil consists of almost pure sand, yellow in color, which continues beyond the reach of the soil auger (1.5 meters).

Fertilizers.—Like most plants of the grass family sugar cane is a rank feeder and rapidly impoverishes soils where it is grown unless special care is taken to restore and maintain their fertility. If nothing but the sugar in the cane were removed from the fields soil exhaustion would not occur, but unfortunately under the ordinary process of harvesting and milling cane, the leaves are stripped off, the stalks entirely removed and the bagasse is burned as fuel instead of being returned to the soil. Cultivation of the stubble is very difficult unless the leaves and tops are burned when dry, which practice is very common in all sugar-growing countries. Where the cane is thus removed and the trash on the field burned there is a constant loss in the soil of nitrogen, phosphoric acid, and potash. The burning of the trash causes a total loss of the nitrogen but the phosphoric acid and potash are partially recovered in the ash resulting from the burning. The mechanical effect of leaving the trash to rot on the field is very beneficial by increasing the total amount of humus in the soil. There are a number of ways of restoring and maintaining the fertility to the lands, and at least three of these should be constantly used by all growers of this crop. As much of the trash and leaves as possible should be left on the ground to decay, leguminous crops should be planted alternately with the sugar crops for the special purpose of restoring the nitrogen elements of fertility in the soil. The common practice of growing mungos on sugar land in Negros is a very practical method for use in the Philippines. There should be a more liberal use of commercial fertilizers. Duggar[1] states that a good cane fertilizer should contain nitrogen, phosphoric acid, and potash in about the following proportions: Nitrogen, 4.5 per cent; available phosphoric acid, 8 per cent; potash, 4.5 per cent.

Conner[2] gives a formula containing 5 per cent nitrogen, 8 per cent available phosphoric acid, and 10 per cent of potash.

This should be applied at the rate of about 600 kilos per hectare in furrows by the side of the cane as soon as the cultivation is begun, and additional applications, in smaller or larger quantities, will prove quite profitable if made during the active growing period of the cane. In the dry portions of the Hawaiian Islands there is a tendency to make very heavy applcations of nitrate of soda dissolved in irrigation water and run over the fields at intervals of three to four weeks. In the districts of heavy rains, like Hilo, sulphate of ammonia is used on account of its not leaching out of the soil. Lime as a fertilizer will prove valuable on the heavy clay soils of the Philippines, particularly when they are first

[1] Southern Field Crops.

[2] Philippine Agricultural Review, Volume IV, page 56.

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being reclaimed after having grown up to grass and brush for a number of years. Lime is not a fertilizer within itself but has the power of decomposing vegetable substances and disintegrating heavy compact soils so as to make the plant food they contain readily available.

The older soils, which have been cultivated in cane for many years should receive liberal applications of the decomposed vegetable matter, such as cane leaves, bagasse, grass, refuse from the barnyard, and animal manures. A system commonly practiced in Negros is to keep all of the work cattle used on the farm in a temporary corral at night and as soon as the land has become heavily coated with manure the corral is moved to a new site and cane is planted in the old corral where it gives excellent yields. Any decayed vegetable matter, trash, or waste about the farm will prove valuable if applied to cane fields.

There are at present probably only two native fertilizing materials which are likely to prove of material value in sugar growing. One of these is bat guano, found to a limited extent in mountain caves where the large tropical bats roost, but unfortunately many of these deposits are so located as to be inaccessible to transportation. Analyses of a large number of samples tend to show that most of them have been subjected to leaching by seepage of water through the soft rock constituting the roof and walls of the caves.

The other is copra cake, the resulting press cake after the extraction of the oil from the ground and dried meat of the coconut. It is a fairly satisfactory nitrogenous fertilizer, resembling in some respects cotton-seed meal so commonly used on sugar cane in Louisiana and the other southern States.

The filter press cake from modern sugar mills is generally utilized as a low grade fertilizing material by returning it to the fields from which it came. It can be transported in carts or on tramways but a more economical means of returning it where irrigation is used is to grind the cake, put it into the irrigation ditches and run it back to the fields in the irrigation water. Low grade molasses, which is not salable, is often returned to the fields, especially where it can be carried by the irrigation water.

CULTIVATION.

Clearing the land.—New lands planted to sugar cane in the Philippines are usually covered with a heavy growth of dense, tall, tropical grasses, sometimes a scattered growth of scrub brush, and occasionally tropical forest. The operation of clearing is comparatively simple if nothing but cogon grass (*Imperata cylindrica Koenigii* Bentham) is growing on the land, and consists primarily in burning it off during the dry season. The burning can be facilitated by running a harrow, drag, or roller over the grass, especially if it consists of the coarser kinds like talajib (*Saccharum spontaneum indicum* Hackel). The land should not be burned over much

in advance of the first breaking as it tends to dry out and becomes hard to plow. On sandy lands, or others that are deficient in organic matter, it is advisable to plow under as much of the grass and other vegetable matter as possible, in order that it may decay and furnish additional humus in the soil. Whenever a growth of wild bananas, tropical vines, or scrub brush is found it is best to grub them out by hand before attempting to break the land, using strong grubbing hoes or mattocks. In such places there will be but little grass and burning is not practicable.

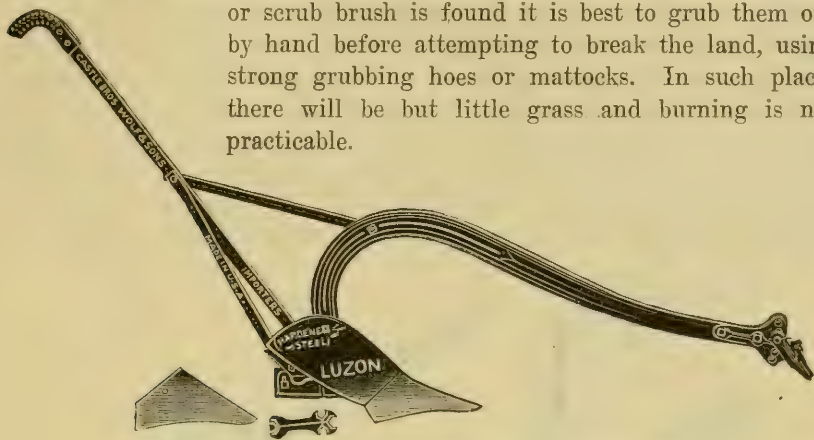


FIG. 1.—The Luzon one-handled steel-beam breaking plow.

The clearing of tropical forest is a difficult and expensive operation, as the trees usually grow in dense jungles, are of the hardwood types, have large buttressed root systems and the stumps are very difficult to grub or blast out, especially in the heavy types of land best suited for the growing of sugar.

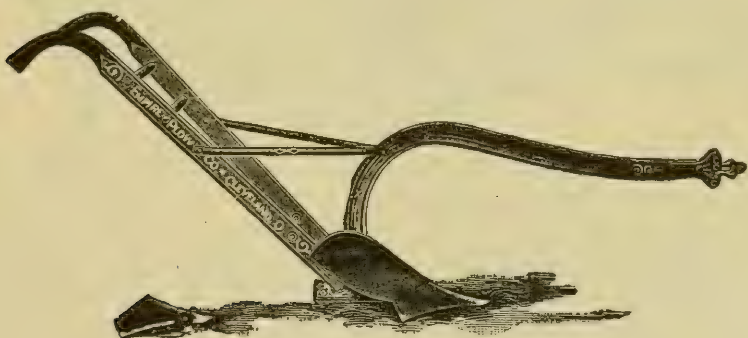


FIG. 2.—Two-handled steel-beam breaking plow.

At the present time most of the new land being planted to sugar was cultivated in cane fifteen years ago or more, and has since become overgrown with grass which burns off annually, thus destroying any tree seedlings and preventing the reforestation of the land.

Breaking.—The breaking of sugar lands which have become over-

grown with cogon and other coarse grasses is difficult on account of the very dense root system which they develop in the surface layers of the soil. In order to thoroughly break up these roots, it is necessary to have very strong plows, fitted with some device for cutting through the grass roots and pulverizing the soil as much as possible so as to secure their exposure to the sun. For this purpose, either moldboard plows with standing and revolving coulters or the disk plows may be used. Moldboard plows should be of the black-land type, having a very long sharp point and the share set at an acute angle with the land slide, so as to make them of easy draft and insure scouring in the heavy clay and gummy lands. Disk plows should be of very strong construction and with extra large disks. The first plowing should be comparatively shallow and should be done some time before the cross-plowing in order to permit the

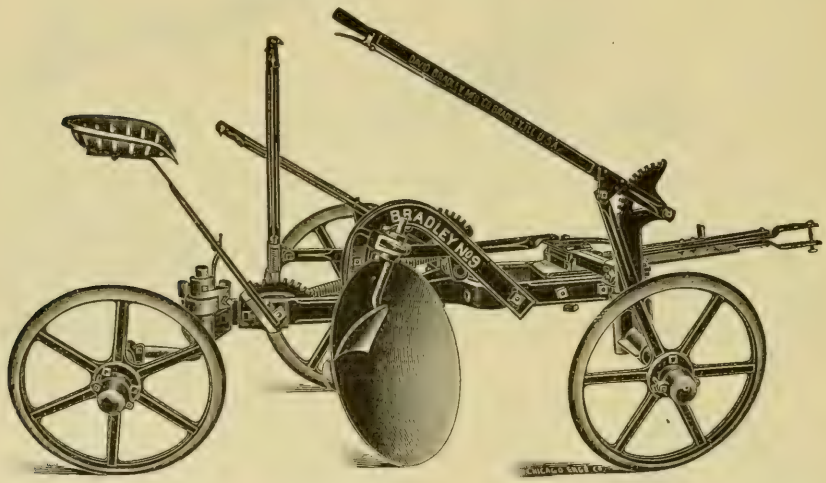


FIG. 3.—Single-disk three-wheeled gang plow.

drying and crumbling of the over-turned sods in the dry season, or their disintegration by water during the rainy season. The cross-plowing can be done with the same implements, but plows having an extra long standard or very large disks are better for this work. Subsoil plows may be used for following the cross-plowing, but there is considerable doubt as to the economy of their use. Disk and drag harrows are essential to the proper pulverization and leveling of the land after breaking. Field rollers, clod crushers, and drags also have a distinct place in the proper preparation of cane lands.

The breaking of land previously planted to cane is a much easier process than bringing new land into cultivation and requires a lighter class of implements with less power to pull them. The native plow and harrow, described by Mr. Walker, are very poor types of implements and

should be replaced as rapidly as possible with those of more modern construction and higher efficiency. One-handled steel plows of foreign manufacture and one of local manufacture at Iloilo are in common use now in Negros and Panay.

Animal power.—The best animal power for use in breaking and cultivating land in the Philippines is the carabao (water buffalo). They are large and powerful but very slow and can only work a portion of the day on account of their susceptibility to heat. The tendency in the sugar-growing districts is to use them more for breaking the land and doing heavy hauling, such as transportation of the cane from the field to the mill and the sugar from the mill to the shipping point, and to use work bullocks for the cultivation of the cane and the other lighter work on

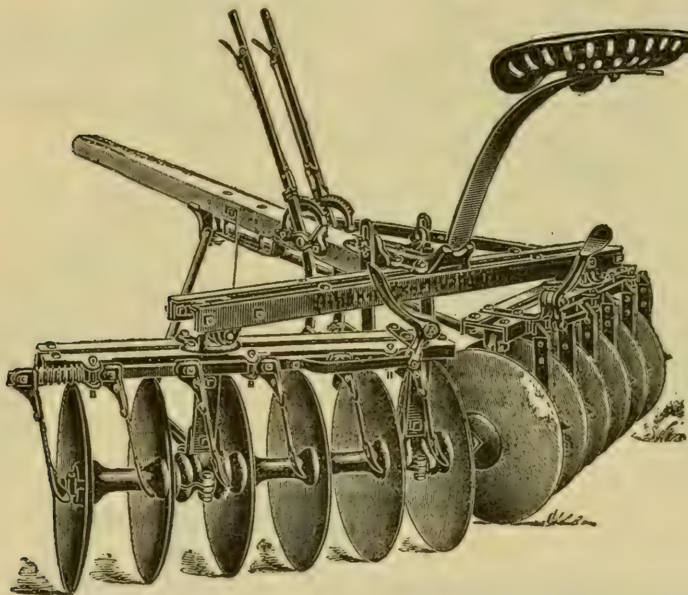


Fig. 4.—Disk harrow.

the plantations. The native ponies are only about 120 to 132 centimeters (12 to 13 hands) in height and weigh on an average not over 250 kilos (650 pounds), which renders them unsuitable for sugar-plantation work, except for light passenger transportation. There are a few places in the Islands where they are used in double teams on American one-horse plows for the breaking and cultivation of land. They are more often used as pack animals for carrying sugar to the market, or as draft animals singly and in double teams for its transportation on carretelas and small wagons. There are only a few instances where foreign mules and horses have been imported into the Philippines for use on sugar plantations and they have generally not proven to be economical for this purpose.

Traction engines.—Traction plowing engines have, for a number of years, been popularly supposed here to serve as a satisfactory substitute for cattle and carabao in doing the heavy work on the sugar plantations. A thorough test covering a period of several years has been made by the Bureau of Agriculture in the use of traction engines, driven across the

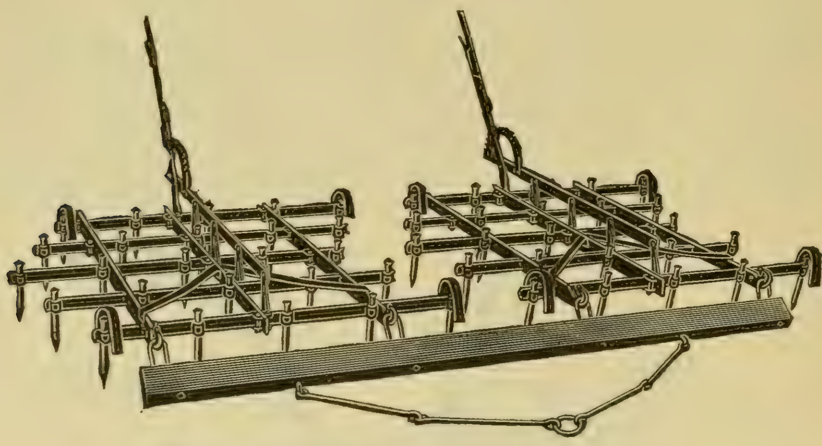


FIG. 5.—Two-section smoothing harrow.

fields for drawing gangs of plows, harrows and rollers behind them. These machines were of the ordinary type with top mounted engine connected by a series of gear wheels from the engine shaft down to a large gear on one of the driving wheels and actuating the other driving wheel through the axle and differential. They have generally ranged in weight

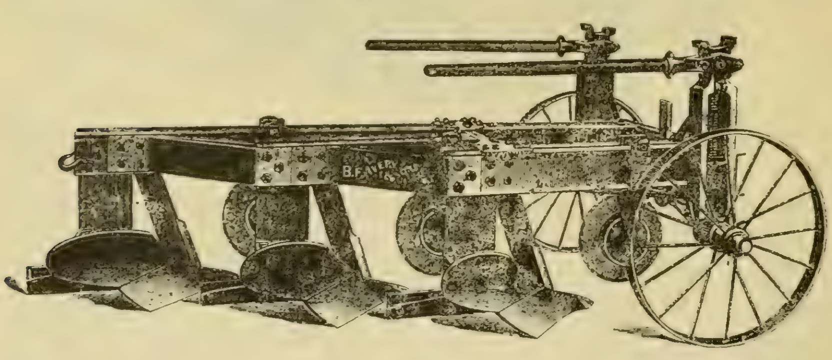


FIG. 6.—Extra-heavy gang plow. (Avery's "Jumbo.")

from 12 to 16 tons when the boiler and tanks were filled with water and the bunkers with coal. They have given fairly satisfactory results on level, sandy land where there were no rice dikes, irrigation ditches or ant hills, and during the dry season when irrigation was available for keeping the land in proper condition to plow. They have proven quite

unsatisfactory on the heavy types of land, both in the rainy and dry seasons. They tend to mire down when the land is wet and are more or less injured by running over the irregular surface of the land when dry, under both of which conditions they fail to develop enough power to propel themselves and draw the plows through the soil. Even when the land was in good condition for plowing, if there was considerable vegetation on it or heavy dews prevailed, difficulty was experienced on account of the choking of the plows and the accumulation of sticky soil on the wheels with consequent slipping. The use of mud hooks results in a

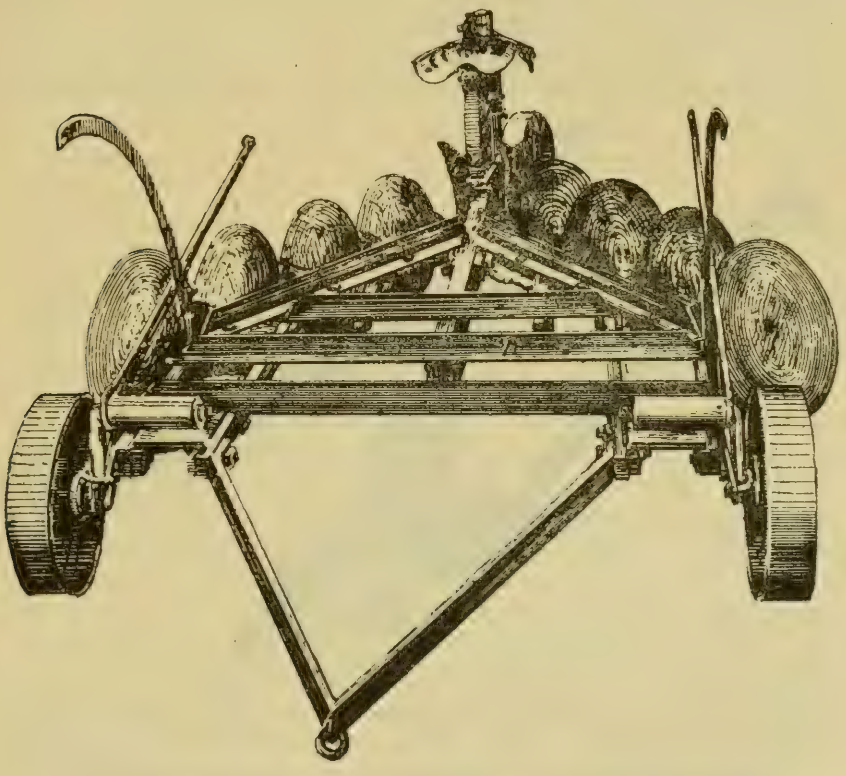


FIG. 7.—Bureau of Agriculture two-way disk gang plow with middle breaker.

distinct loss of power in both wet and dry land and after the wheels have become thoroughly gummed with the sticky dirt the mud hooks are almost useless in preventing slipping. These engines have also proven extremely difficult to move about the Islands on account of the necessity for using water transportation between ports and passing over bad roads and flimsy wooden or bamboo bridges.

A two-cylinder petroleum engine, starting on gasoline and weighing only about 9 tons, has been tried with a little better success. It is also much more convenient on account of not requiring water and using a

condensed liquid fuel, particularly in isolated sections where water is scarce and the transportation of coal is expensive. However, machinery of this type requires the services of an experienced gas engineer to keep it in repair and operation.

Automobile farm motors.—It is the opinion of the writer that a still lighter form of traction machine of simple construction will be better than either of these. The nearest approach to this class of machine, at the present time, is the automobile truck. There is reasonable doubt as to whether the automobile gasoline engine will prove successful under such conditions. The accompanying illustration shows a truck of this type recently placed on the market here and which has apparently given very satisfactory demonstrations of the wide range of work it is capable of doing. Steam engines are much simpler both in construction and operation

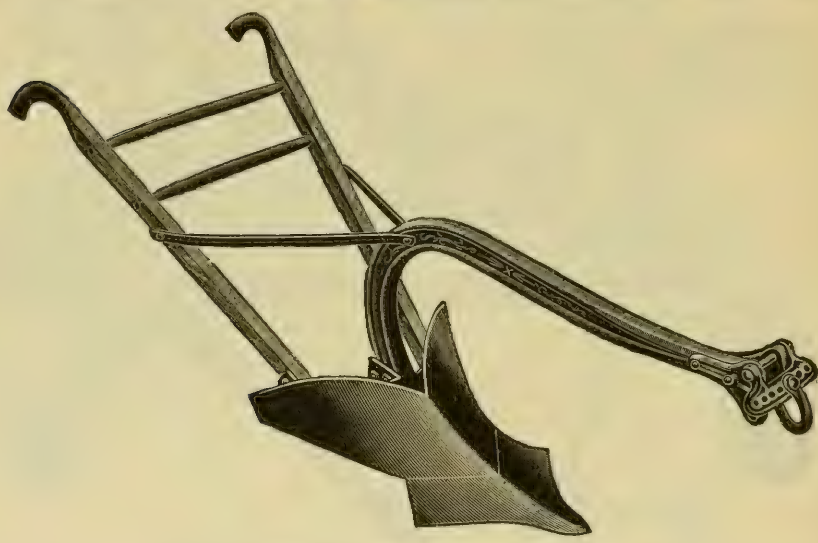


FIG. 8.—Middle breaker and furrowing-out plow.

than those using gasoline or petroleum, and it is highly probable that the most successful type of truck would be a modification of a simple form of steam wagon manufactured in Great Britain. It has a high pressure, top-fired, vertical boiler, a double cylinder engine mounted horizontally just in front of the rear axle, and short-chain drive. For farm work the rear wheels must be fitted with very broad tires and automatic folding mud hooks, and there should be a long draw bar across the rear of the bed for attaching plows and harrows. Such trucks could be used for the transportation of cane to the mill or any other heavy hauling, and have attachments for the operation of cane loader, a mowing machine, or reaper attached to the side of the bed, and many other useful combinations for special work on the farm.

Cable plows.—So far the most successful type of power plow is the

steam cable outfit, consisting of two engines operating on parallel plantation roads and drawing the gang of plows, harrows, and other implements across the intervening land by means of cables wound on horizontal drums underneath the boilers. These engines are manufactured principally in England and can be operated either as traction or cable plows. The gear from the engine shaft may be connected with the driving gear of the traction wheels or with that of the cable drum, either of which may be operated at pleasure. The machines are run alternately for drawing the plows toward the engine in operation; when the plow arrives at one engine the gears are released from the cable drum and engaged with the driving wheels so that the engine propels itself forward the width of the swath cut by the plows. Some of the disadvantages of this class of machines are that they are expensive, difficult to transport by water or over poor bridges, necessitate the construction of roads on the plantation, and are difficult to move across fields where there are such obstructions as trees, large rocks, and cañons.

Heavy gang plows.—Special heavy gangs of plows should be purchased for use with all traction and cable plows. The "balance plow," sold by English dealers with their cable plowing engines, generally gives good results in quality of work and is about the only form of gang that will stand the heavy duty demanded. The "Jumbo," an American gang plow, with the frame made of angle steel 20 centimeters in width and the other parts correspondingly strong, would no doubt prove a valuable implement, especially for breaking new land filled with the roots of scrub brush or where dhobie stone is near the surface. The Bureau of Agriculture devised a form of disk gang plow having six disks turning to the right and six to the left with a middle breaker in the center. It was made for use with a steam traction engine for breaking heavy black land. It works well but has the disadvantage of putting the land up into high ridges which are hard to work down before planting. The land must be thoroughly broken long enough before planting to permit the decay of vegetable matter, and the soil should be thoroughly cleaned and pulverized by replowing and harrowing before putting out the points.

Method of propagation.—Sugar cane is generally propagated in the tropics by planting points or cuttings taken from the immature tops of the stalks. Outside of the tropics, in such countries as Louisiana where cane never grows to full maturity, it is generally propagated by planting the whole stalk. In the tropics the eyes on the lower portion of the stalk generally fail to germinate when cane has gone through a long growing period. When it is desired to make plantings of whole stalks in the tropics it is necessary to cut them before they reach maturity. The generally accepted plan of propagating by points has many advantages to commend it, particularly in that the tops of

the stalks have very little sugar-producing value and actually injure the juice from the other portions of the stalk by increasing the amount of invert sugar which it contains. Their removal does not materially decrease the total amount of sugar which can be harvested from a field.

When plantings are made during the dry season and the points placed vertically, the lower ends extend down deep enough to absorb the scant moisture as soon as the fibrous roots begin developing.

Time of planting.—The points are generally cut during the milling season just after the cane has been stripped and before it is cut down. They are then thrown into piles and carted away, usually to a stream or other place where water and shade are found. The leaf sheaths are removed by hand, generally by women and children, after which the points are tied into bundles of about one hundred each and these are thrown into the water where they are left until germination begins. They are then removed and taken to the field, which has been previously prepared and are planted as rapidly as possible before drying out occurs.

The time of planting in most parts of the Islands is simultaneous with milling and extends generally from December until April. However, in sections like Negros with a good soil and a well-distributed rainfall, planting can be made at almost any season except, possibly, during the period of heaviest rain which occurs from July to October.

Method of planting.—The laying off and furrowing out of the rows should be done just ahead of actual planting. This can be done with a turn plow run twice in the same furrow but is more commonly accompanied by the use of the middle breaker.

The width of the rows is a question on which there is a great difference of opinion, but cane is generally planted in tropical countries in rows from 1 to 1.70 meters apart. The tendency in the Philippines, where the small rapidly maturing varieties of sugar cane are grown and where no fertilizers or irrigation are used, is to plant in narrow rows. A great deal of the cane in Pampanga Province, where the stalks rarely mature much more than 1.5 meters in height, is planted but little more than a meter between the rows. In heavier types of land, particularly in Negros, the rows are often 1.2 to 1.6 meters apart. The rows on level land may be laid off in straight lines between the plantation roads used for transporting the cane, but where the land is hilly enough to wash, the rows should be run horizontally around the hillsides. Where irrigation is used the rows can be so placed as to have a slight fall, which will greatly facilitate the running of the irrigation water along them.

The furrowing out of the rows should not be done until everything is in readiness for planting as the land readily dries out and the percentage of germination is decreased. After the points have been cut

and prepared, as previously indicated, they should be hauled to the field where laborers are held in readiness to put them into the ground with as little delay as possible. This is accomplished most economically by the employment of women and children who take the bundles of points, pass along the rows, and stick them down through the loose earth into the bottom of the furrows until the tips only are visible above ground. They are generally set at an angle of about 45° in single or double lines, using from 20,000 to 30,000 points to a hectare. If the loose earth in the bottom of the furrow is not sufficient to cover the points as desired, the planters may rake in additional dirt from the sides of the furrow with their feet, hands, or hoes. Under this system of planting plows are very rarely used for covering the points. It is a common practice in many parts of the Islands to have the plant-

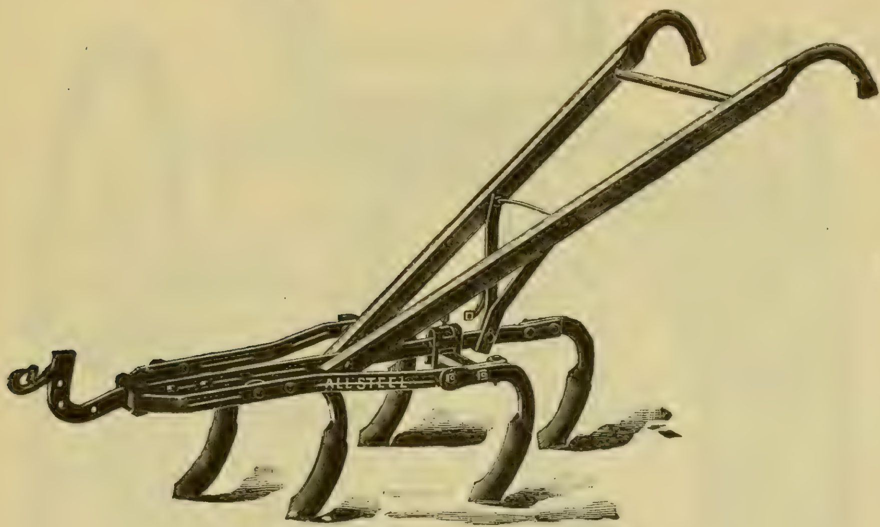


FIG. 9.—Five-tooth cultivator. (Planet Jr.)

ing done by contract, the unit being a *lacson* of 10,000 points. Many of the planters in Negros determine the area planted from the number of *lacsons* of points put out by the contractors.

It would not often happen that the planting of whole canes could be resorted to in the Philippines, but when this system is used it would probably be in the rainy season when the cane was immature and could be planted by simply cutting down the stalks and laying them horizontally in the furrows, after which they could be covered to a depth of 5 to 10 centimeters with a small plow. In some cases the leaves or leaf sheaths are removed, but in Louisiana most of the fall planting is done with the leaves on the freshly cut cane.

Cultivating.—It is very important that young cane be thoroughly cultivated in either the dry or rainy season, as in the former it greatly

assists in the conservation of the soil moisture and in the latter is necessary for the destruction of weeds. Cultivation is most easily accomplished by the use of small implements drawn by animal power, but some hand hoeing is generally required in order to destroy the weeds in the cane drills and fill up the old furrows in which the points were planted. For the latter purpose the ordinary garden or field hoe with a long handle is preferable. The short-handled hoes used

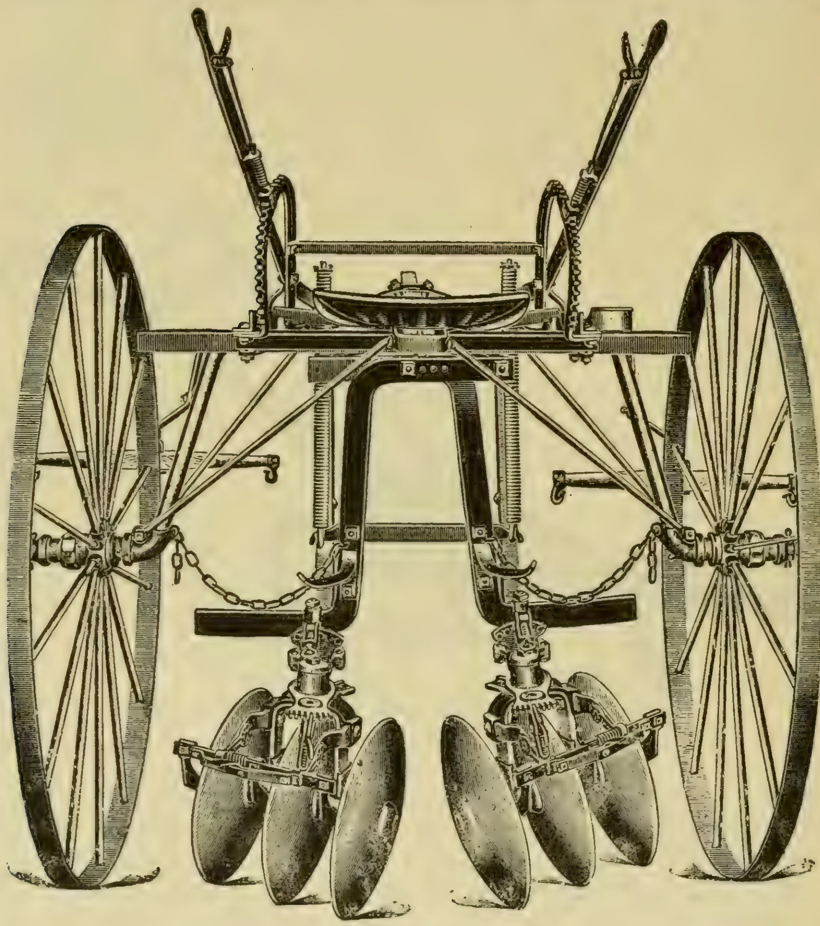


FIG. 10.—Riding disk cultivator.

in Java and the long-bladed hoes of Japan and China are unsatisfactory implements, lacking many of the mechanical advantages of the American hoes.

Cultivators.—Several forms of implements are used for cultivating cane. The small five-toothed walking cultivators, like the Planet Junior, drawn by a single animal, are best adapted to the small sugar farms of the Philippines. They are not expensive and are easily kept in

repair. Another form of 4 or 5 toothed cultivator used extensively in the southern States of America for the cultivation of young cotton is known as the *side harrow* and would be excellent for the cultivation of young sugar cane in clean, sandy land. There are many forms of these small cultivators, all of which have some special feature of recommendation. One which deserves special mention is a combined harrow, weeder and cultivator.

Riding cultivators are not very well adapted to small plantation work in the Philippines, but will no doubt come into common use on the large plantations. They are of two general types. One is fitted with a gang of small plows running on either side of the cane rows and so set as to throw the dirt toward the cane or away from it as desired;

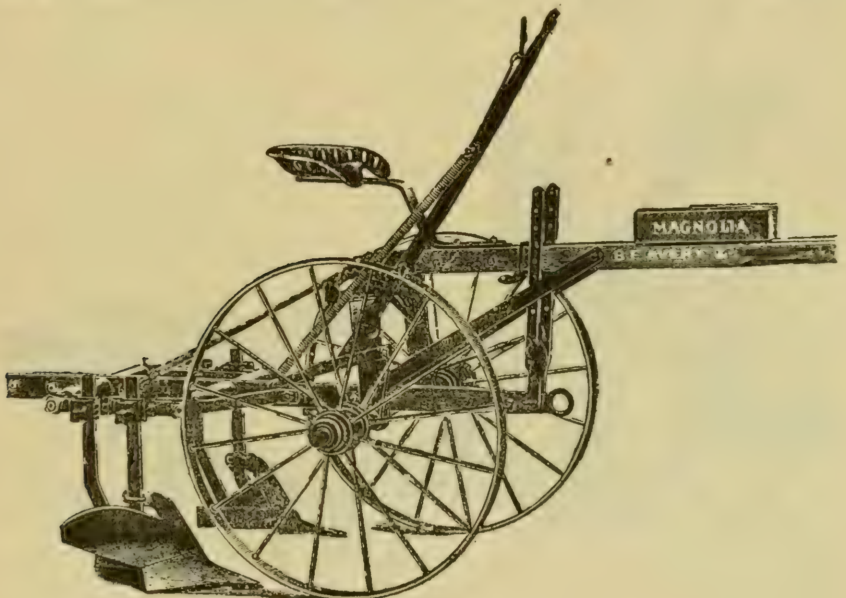


FIG. 11.—Two-way gang plow for barring off stubble or ratoons. (Avery.)

and the other has two gangs of disks usually of three each, which replace the plows mentioned in the other form. Both of these are two-wheeled implements with pole, doubletree and driver's seat. They are generally built for use with horses or mules, but could be easily adapted to work with carabao or bullocks if a double yoke with bows were used. They are said to be of lighter draft, more rapid and require less labor for their operation than the walking cultivators. There are also forms of cultivators drawn by steam cable plows which are said to be serviceable on the larger plantations having such expensive machinery on hand.

The most common implement used in the cultivation of sugar cane in the Philippines, outside of Negros, is the native wooden plow with

its crude cast-iron point and share. These run to a depth of from 5 to 10 centimeters which is too deep for shallow-rooted crops like sugar cane, and cut a furrow from 10 to 12 centimeters in width, thus making them of low efficiency in covering land on account of having to make four to six furrows in each row.

When plows are to be used for cane cultivation a better form is the steel plow with land slide and adjustable clevis so that they can be set to run just deep enough not to injure the cane by cutting off the roots.

Cane planted in the early part of the dry season usually reaches sufficient height to have a leaf spread great enough to shade the entire

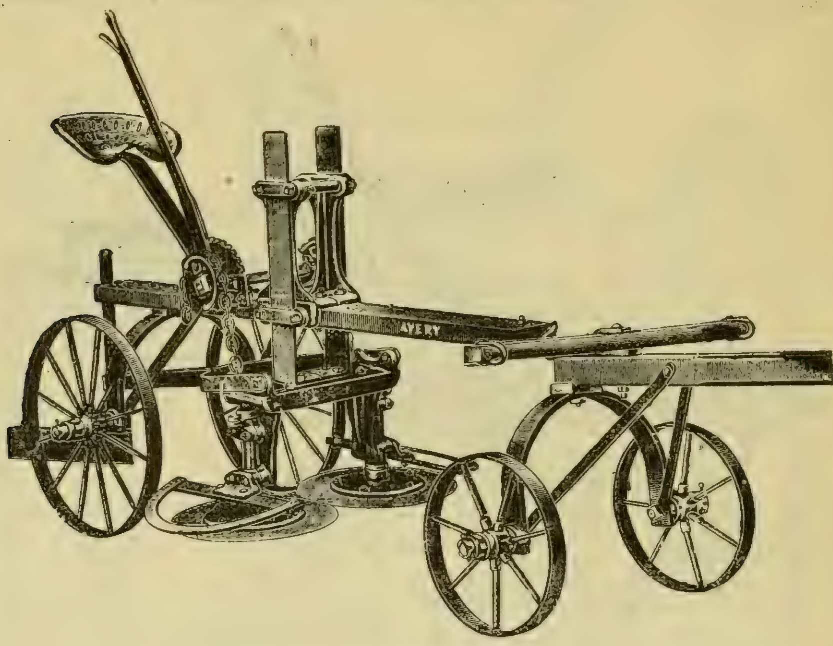


FIG. 12.—Horizontal-disk stubble or ratoon shaver. (Avery.)

land which it occupies in from three to five months after planting, the time depending on the width of rows, the variety of cane, the fertility of the land, the time of planting with reference to rainfall, and the subsequent cultivation which it receives. It is generally "laid by" or abandoned so far as the further cultivation of the soil is concerned after the leaves have lapped in the middle of the rows. Except for missing places very few weeds or grasses will grow on the land after this time, and the shading by the cane conserves the moisture quite as well as cultivation. From this time until harvesting it usually receives no attention except to be protected against the ravages of insects, animals and floods. The protection of cane against the de-

structive effect of winds can only be done by its general location, the placing of wind breaks and other measures which are not particularly applicable to a single crop.

The growing period.—The total time from planting to harvesting the sugar cane in the Philippines varies from eight to fourteen months and probably averages ten to eleven months. Cane planted sometimes as late as the end of April or the first of May is harvested in December and January, but the great bulk of the crop is planted during the months of January, February, and March and harvested in from ten to twelve months.

The harvesting of the 1911 crop in Negros was not completed until nearly the first of June on account of scarcity of labor and much of the cane grew through a period of twelve to fifteen months without arrowing.

Ratoon crops.—The eyes on the rootstock below the surface of the ground generally retain full vitality even in tropical canes growing to maturity during a very long period. This makes it possible to produce one or more crops of stubble or ratoon cane succeeding the harvest of the first or plant cane crop. The total number of ratoon crops which can be produced varies with the climate, soil fertility and method of cultivation. In Louisiana one or two ratoon crops are secured while four or five are often harvested in Hawaii. It is said that cane continues to produce for as long as fifty or seventy-five years from a single planting in the richer portions of Cuba.

Sugar planters of Negros rarely ever take more than one or two ratoon crops and the majority of them tend to replant the cane every year. In Pampanga, and all of the other sandy land districts, it is almost invariably planted anew for each crop.

The harvesting of the cane and the simultaneous planting of the new crop in the Philippines requires so much labor of men and animals that there is always a tendency to neglect the ratoons that are carried over for a second or subsequent crop. Many times the field is burned over by accident and the young cane which may have come up is destroyed. The stand is often permanently injured if the trash is deep and the land dry when the burning occurs. It would be easy to avoid this by raking the trash into the middle of the rows and burning it soon after harvesting the cane. A still better system, especially for poor lands, is to rake the trash into the middle of the rows and cover it with dirt so that it will decay and add vegetable matter to the land. For this purpose a turn plow may be run on both sides of the rows so as to bar off the stubble and throw the dirt to the middle of the rows. An improved implement for doing this work is a double gang barring-off plow built on the same plan as the wheel cultivators. It carries two share plows, one turning to the right and

the other to the left, and adjustable to the desired depth and width apart. The wheels run in the furrows between the rows just ahead of the plows and press down the trash so that it is easily covered. A valuable improvement could be made on this implement by putting two or three hay rake teeth on each side of the pole so as to rake all of the trash away from the stubble, throw it under the wheels and thus secure thorough covering. The teeth should be arranged one slightly behind the other from the pole out and be provided with hand or foot levers for dumping them in case of clogging.

Another necessary implement for this work is the stubble shaver.

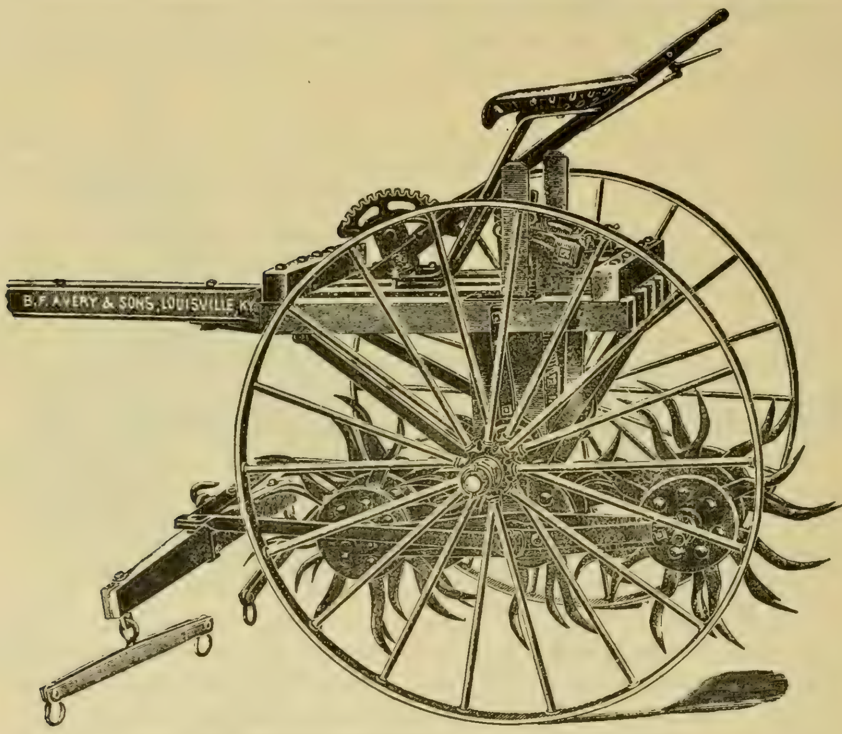


FIG. 13.—Three-cylinder stubble or ratoon digger. (Avery.)

It runs on four wheels, carries two horizontal disks overlapping each other, sometimes a vertical disk in front of these and a "V" shaped steel drag behind them. When driven along a row of cane stubble the vertical disk splits the roots and dirt in the center of the ridge, the horizontal disks cut it down to any desired height and the drag, the apex of which follows the line cut by the vertical disk, throws the cut stubble to the middle of the rows.

After barring off the stubble shaver should be run over the rows so that the horizontal disks will cut the root stocks down to a few eyes at the bottom. In the tropical countries soils tend to pack down very

Fig. 1.—SYSTEM OF BRINGING CARS OVER PORTABLE FIELD TRACK, EWA PLANTATION, HAWAII.

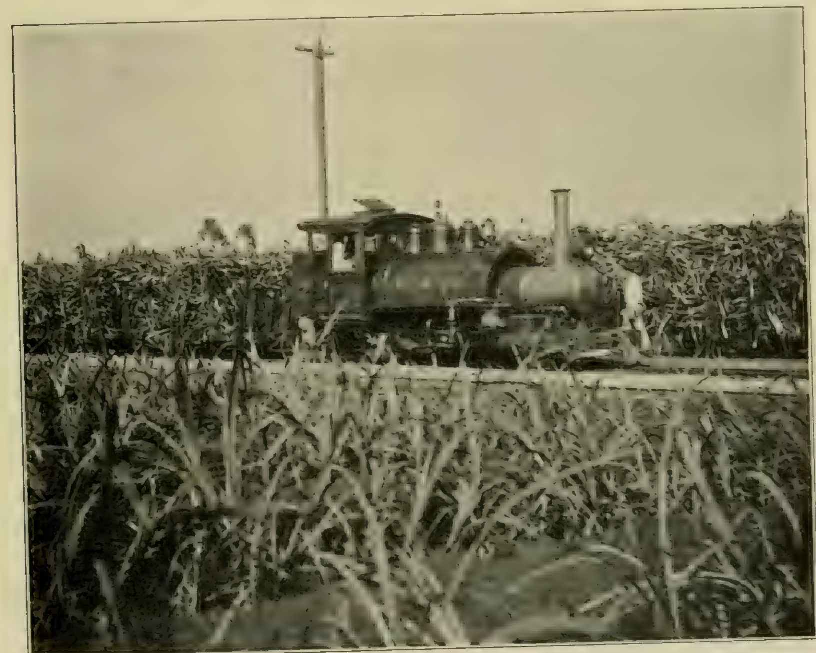


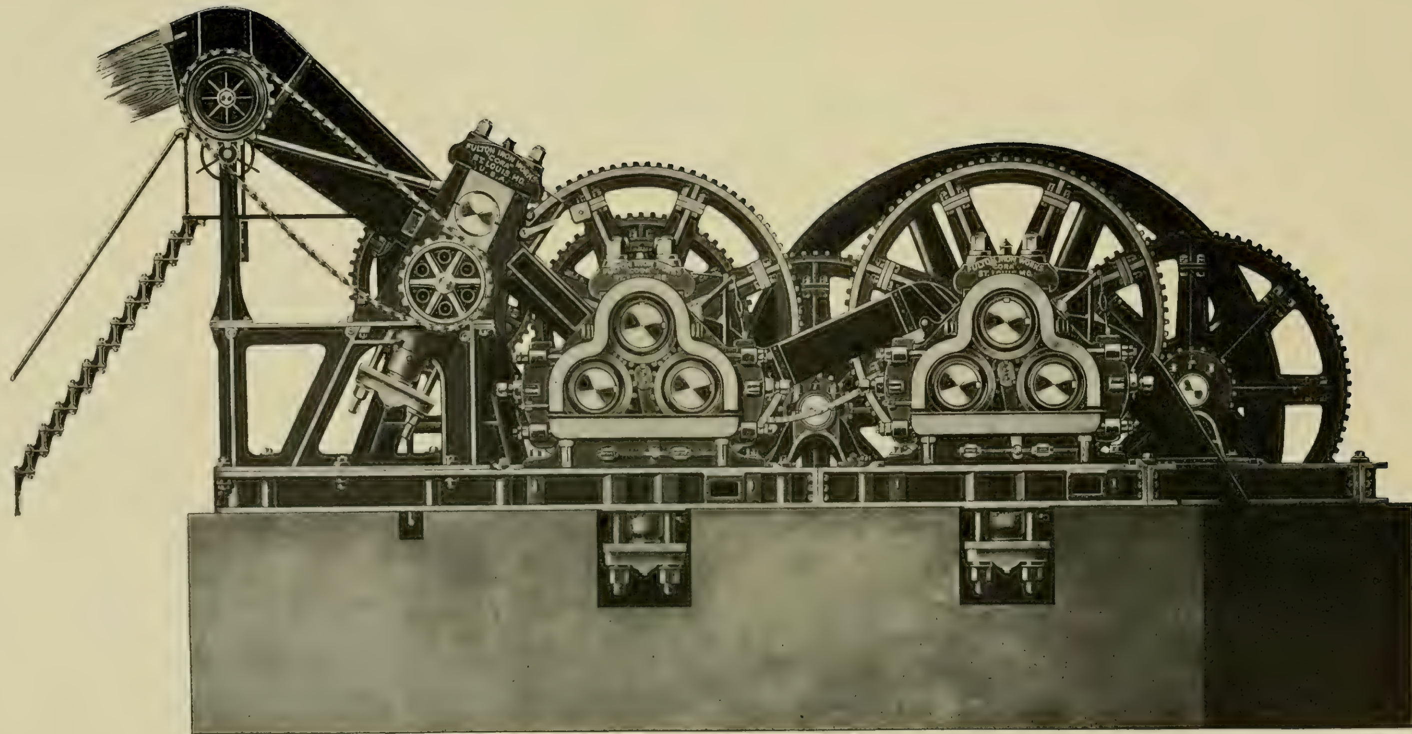
Fig. 2.—PLANTATION SUGAR RAILWAY TRAIN EN ROUTE TO MILL, WAIALUA PLANTATION, HAWAII.

PLATE XII.

Fig. 1.—EWA MILL, ISLAND OF OAHU, HAWAII.

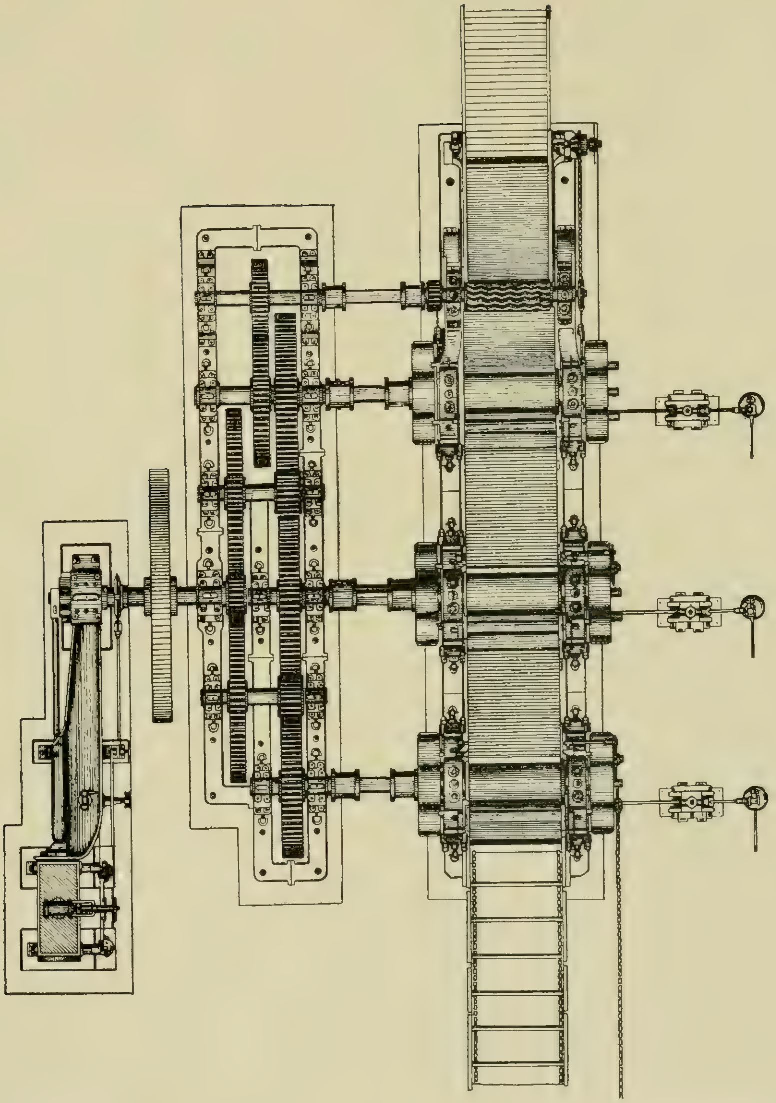
Fig. 2.—WAIALUA MILL, ISLAND OF OAHU, HAWAII.

PLATE XIII.



SIX-ROLLER MILL WITH CRUSHER AND HYDRAULIC JACKS. (Fulton.)

PLATE XIV.



NINE-ROLLER MILL WITH CRUSHER, GROUND PLAN SHOWING ARRANGEMENT.
(Honolulu Iron Works.)

PLATE XV.

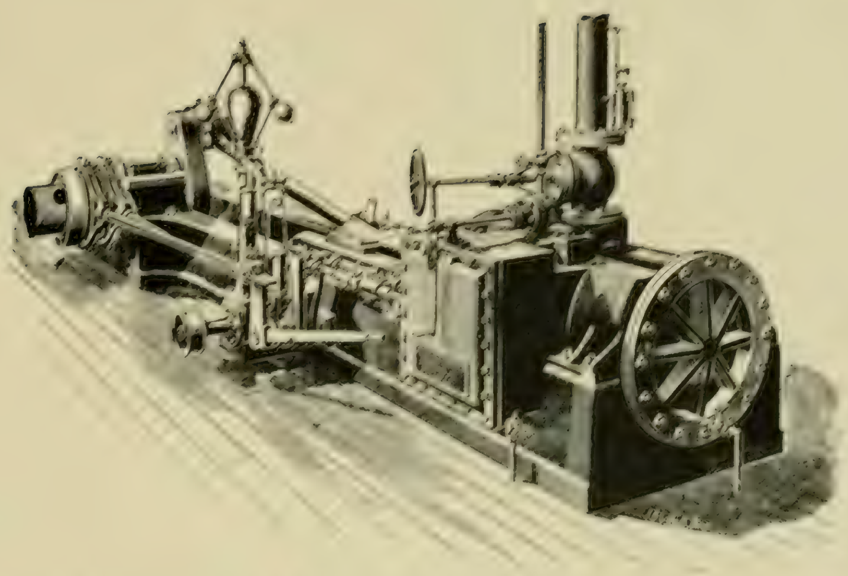


Fig. 1.—HEAVY-DUTY SLOW-SPEED ENGINE USED FOR DRIVING SUGAR MILLS.
([illegible])

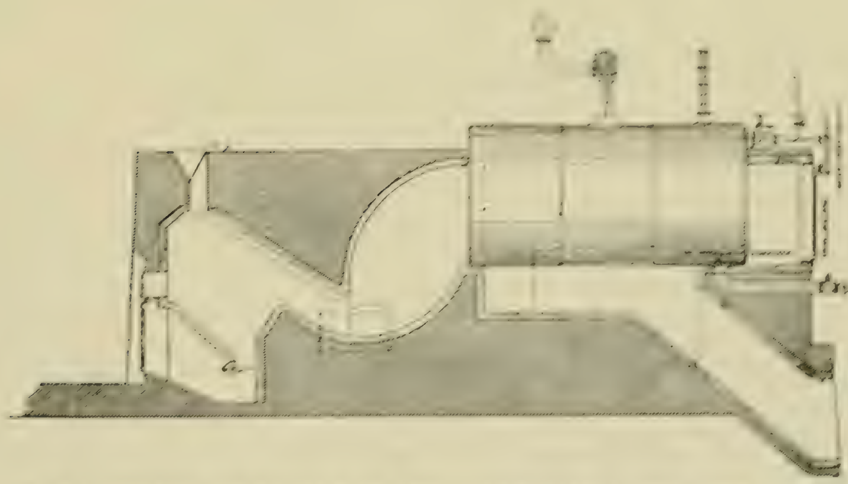


Fig. 2.—MULTITUBULAR BOILER WITH IMPROVED BAGASSE FURNACE AND STEP LADDER GRATE. (Harvey Engineering Co.)

PLATE XVI.

close during the rainy season and is one of the causes for such poor results with ratoons. This can be overcome only by breaking the ground around the roots, which is impossible with ordinary plows. The stubble digger is a special implement for doing this work and is commonly used in all the leading sugar countries. It is also a form of wheeled cultivator with two or three sets of picker wheels carrying curved steel points. It is run just behind the stubble shaver so that the pickers pass over the freshly cut stubble and the teeth are driven full length into the ground among the rootstocks. The teeth have a peculiar curve which gives them a spading motion and thoroughly breaks up the ground around the cane roots. The irrigation, fertilization and cultivation of the ratoon crop is otherwise the same as for plant cane.

When ratoons are neglected and left on the top of the old cane rows only those eyes near the surface of the ground germinate. If barred off and shaved down so that the new shoots are in the bottom of a furrow just as the points were when planted, they get a better water supply during the dry season, are easier to cultivate, and produce a much better crop of cane. On account of the heavy cost for replanting the cane every year considerable expense in caring for the ratoons is justifiable. Even a smaller crop is acceptable provided the difference between its value and that of the plant cane crop is not more than the difference in the cost of production.

HARVESTING AND TRANSPORTATION.

The harvest season.—The long growing period of cane and a tendency to ripen slowly permits some delay in beginning and the extension of the time for harvesting the crop over a much longer period than would be possible with those like rice and tobacco. Unless unusual winds, rains or dry weather prevail or the cane arrows some time before it can be harvested, no serious damage will occur in such climates as that of the Philippines for four to eight weeks after the customary time of harvest. With a good tropical climate having no well-defined seasons the time of maturity may be controled to a large extent by extending the planting over the same period desired for the harvest so that the different parts of the crop ripen in regular succession. The labor should be in readiness, ample and efficient transportation available, and the mill in thorough working order. The harvest season is very exacting on account of the necessity for taking off the crop, marketing the sugar, caring for the stubble, and putting out the new crop of plant cane all at the same time. Scarcity of labor, break-downs of the mill, animal diseases, and bad weather are among the causes for delay in harvesting the crop, and all possible precautions should be taken to avoid them.

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Economizing labor.—The Philippines are like most of the sugar-producing countries in that the available labor supply is comparatively limited. Under the present system of very small plantations and mills the amount of labor required per ton of sugar produced is much greater than it would be if a better system of management were inaugurated and more labor-saving devices used. The argument is sometimes presented that high salaried management and expensive labor-saving machinery tend to make the cost of the work done greater than when the native laborer, paid small wages, is left to take his own time and use his own methods for doing the work. Even admitting the truth of this claim, a sufficient argument against it is the fact that the limited labor supply available necessarily limits the amount of sugar that can be produced on a given plantation and in the whole Islands. It should be so economized and augmented that the amount of manual labor now required to produce a ton of sugar will produce more and more each year, especially with improved methods and equipment.

Laborers often work twelve and even fifteen hours a day during the heaviest part of the grinding season. It is customary and they do not complain, but not being very strong or well fed, they become fagged out in a few days and drag through the balance of the season in a desultory manner or quit work altogether, generally under the pretense of being sick. Shorter hours would result in more efficient labor, conserve the strength of the men for a longer period, and reduce the demand for holidays.

The common diet of fish and rice provided for the laborers is no doubt the most economical so far as actual cost is concerned, but it could be greatly improved by giving a greater variety of food and more meat. The effect of an abundant and wholesome diet is quite evident in the excellent physical condition of the Philippine Scouts, Constabulary soldiers, Coast Guard sailors, and Bilibid prisoners.

With the coming of the central mill the system of harvesting at a number of places or small plantations at the same time will be changed so that one large gang of laborers will work in a limited section along the temporary tracks of the plantation railway, which will prove much more economical than dividing the labor employed on the area from which the central mill draws its supply of cane into the large number of squads represented by the present small plantations. A large part of the labor now employed by the small mills during the harvest season, such as for driving carts, unloading cane at the mill, loading and unloading cars, handling and drying bagasse, hauling sugar to the port of shipment, and many other laborious tasks will be accomplished by mechanical power or dispensed with altogether.

Stripping the cane.—The first process in harvesting sugar cane is the stripping the leaves from the stalks, an operation requiring much

time and labor as it must be done by hand. It is best accomplished by the use of a cane knife or bolo, which the laborer passes down each side of the cane, knocking the leaves off and throwing them out into the middle of the row. The cane strippers also cut off the top, leaving the stripped canes standing in their usual position in the row. The cane is subsequently cut down with a cane hoe and thrown into piles along the rows so arranged that the transportation men can gather up each pile as an armful and take it to the carts, wagons or cars used for transporting the cane. Where the dead leaves are left heaped up around the roots of the cane the stripping is imperfect, results in loss by cutting the cane above ground, and in carrying an excess of trash to the mill.

Transportation.—The common method of transporting cane from the field to the mill in the Philippines is by the use of a cart having a low-staked bed and generally drawn by a single carabao or bullock. When two animals are used they are either driven tandem or one is hitched outside of the shafts. Wagons are very rarely used, double yokes with bows are almost unknown, and are not likely to become popular with Filipino laborers. Small narrow-gauge tramways with one-ton cars drawn by bullocks are used to some extent in Negros, but are very rarely seen elsewhere in the Islands. This means of transportation deserves more extended use on account of its economy, but is only applicable where the sugar grower has considerable means with which to purchase and install the system. The larger plantation railways using up to 6 and 8 ton cars in trains drawn by locomotives are not used at the present time in the Philippines, but are certain to be installed by all of the large mills owning and operating their own plantations. By maintaining a system of permanent tracks well located in the sugar fields, with frequent switches from which portable tracks can be laid directly into the cane fields, the tramway can be made to take the place of all other forms of transportation. The portable spur tracks are laid in regular succession from 50 to 75 meters apart through the cane fields, the cars are switched out on these tracks, and the laborers load the cane directly into the cars by hand. The cars are then switched in on the permanent sidings with animals where the rails are heavy enough to permit the use of locomotives, after which they are made up into trains of suitable length and hauled to the mill.

In Louisiana and many other sugar-growing countries the regular commercial railways make a satisfactory freight rate on cane so that it can be transported long distances to the central mills. Specially constructed cars of heavy carrying capacity are generally used and on arrival at the mill are unloaded promptly to avoid demurrage charges.

The shipment of sugar cane by water is practiced in other countries and can no doubt be resorted to in many places in the Philippines. It will prove most economical along the coasts, lakes, and larger rivers where

there are no good roads, and for bringing cane into the mill from comparatively long distances.

The transportation of cane from field to mill by fluming after the system practiced in the Island of Hawaii may occasionally prove practicable in the Philippines where there is heavy rainfall and where there are mountain streams having a constant flow available. This is a very simple form of transportation. The flume consists of a V-shaped box made of two wide boards nailed together and made continuous by joining the ends. It is generally constructed on a light wooden framework giving the flume a constant and gradual fall, which could not be obtained by placing it on the surface of the ground. It may discharge the cane directly into the mill or a storage flume from which the mill supply can be taken as desired.

Loaders.—There are many forms of cane loaders designed for handling the cane in all quantities from the small piles in the field to large carloads, but few of these are likely to have any extensive use in the Philippines except with the large mills and plantations. One of the simplest forms is a light steel derrick on a cart or wagon provided with a sling or grab for picking up the cane from the ground and is intended primarily for hoisting the cane on to carts or wagons which are driven alongside of it. This form of loader is operated by a single animal hauling on the end of a rope reeved through a set of pulleys.

A new style of mechanical loader for wagons has recently been exhibited in Louisiana. It is built on the general plan of the automobile truck with the mast and boom on the rear of the bed. The grab and hoist are operated by the engine which drives the truck.

A common form of hoist or loader used in Louisiana for discharging carts and wagons into railway cars is a traveling crane working over a railway on a steel track placed horizontally overhead across the railway track. There is room by the side of the railway for driving the cart or wagon underneath the loader. The grab is let down and fastened to the slings after which it is hoisted by animal or mechanical power and the crane moved across on the overhead track until it comes over the car into which it is discharged. There are many forms of steam and gasoline loaders which operate on a derrick car and may be taken on the plantation railway tracks to any point on the farm where loading is to be done. They are of the boom derrick type and vary in capacity from a few hundred pounds as when unloading small sleds in very rugged or muddy country, to those having a capacity sufficient for transferring loads from large cane wagons, cars or barges. A Japanese engineer at one of the plantations in Hawaii devised a plan to elevate the front wheels of the cane loader car so that after the load has been hoisted up and the boom passed around over the car, the mechanism can be released and the rail weight will throw the boom back into place by gravity. A rope or chain sling is placed in the body of the cart or wagon, the hook

of the hoisting rope or cable is hitched to the sling, and the entire load is hoisted out of the vehicle. A very convenient form of sling for transferring cane by gasoline loader from sleds to cane cars in the Island of Hawaii is made in two parts with separable hinge device in the center which can be opened by pulling a rope and discharging the entire contents of the sling into the car when it is in proper position.

The storage of daily supply.—The small mills using cart transportation generally discharge all of the cane from the carts onto the ground from whence it is taken by hand and fed into the mill. Occasionally a cane carrier is used and a part of the carts are discharged directly onto the carrier, which feeds it into the mill. When carts are not discharging cane onto the carrier the load is kept constant by transferring the cane by hand to the carrier from where it has been placed on the ground. The more modern mills using railway transportation have very long cane carriers onto which the cane is discharged from the cars at such rate as to keep all parts of the carrier constantly loaded. When carts, wagons, or cars are discharging onto the ground the cane may be placed on the carrier direct by hand or a power grab, but when large quantities have to be discharged into the yards it is usually necessary to load the cane onto cars by means of a heavy derrick and run these down the tracks to the carrier where it is discharged in the same manner as when received directly from the field. The larger mills having ample capital to provide the equipment necessary for the economic operation of the factory generally have an ample supply of cars for storing a supply of cane sufficient for the operation of the mill from ten to twenty-four hours. The amount of cane harvested and transported to the mill during day-light is generally sufficient to keep the mill supplied for at least twenty-four hours. When an abundance of cars are available a surplus over this is also maintained in order to avoid the stopping of the mill should an accident occur on the transportation line.

Weighing.—A definite knowledge of tonnage yield and accuracy in the results of milling can be had only when the weight of cane harvested and delivered to the mill is known. It is necessary to weigh all cane received at the mill and to carefully check every process during its manufacture. The most common form of scales to be used for weighing cane are the wagon scale for carts or wagons and railway track scale for cars. The loaded cars are run over the scales, weighed, and after being unloaded the empty cars are weighed and the difference taken as the amount of cane delivered on the carrier. This is the point at which the official weights for the purchase of cane, the payment of contracts based on tonnage or the division of the crop are generally taken. The scales should be under a shed, kept in good repair, and tested regularly for accuracy.

Unloading.—There are many means of unloading cane, the simplest of which is to take it from the carts or other means of conveyance by hand. In many countries where carts or wagons are commonly used they are made with hinged beds so that by tilting up the front end, the entire contents are dumped onto the cane carrier or ground as desired.

Where cane is loaded directly onto the cars by hand in the field and transported to the mill yard for storage in the cars until it is ready for discharge onto the carrier there is no further work required, which is a great advantage in countries where labor is scarce or high priced. Cars are generally discharged by a large mechanical rake having a universal motion which enables the operator to move it at any height from the body of the car to the top of the load over the entire length of the car at any desired rate for keeping the carrier evenly loaded.

MILLING.

Sugar-cane milling under modern methods may be divided into four essential processes, namely, the extraction of the juice from the cane, the clarification of the juice by boiling, the evaporation of the juice so as to reduce the sugar to the crystalline form, and the freeing of the sugar from impurities.

For accomplishing these processes a great many machines and devices have to be used. They are all generally arranged in compact form in a substantially constructed building designed for the purpose. A brief popular description of a modern sugar-mill equipment and its use is given for the benefit of those who may be in need of elementary information on this question.

Cane carriers.—All modern mills are equipped with some form of carrier for transporting the cane from the point of discharge from vehicles, cars or barges outside of the mill house to the crushing plant inside. These carriers generally consist of a strong wooden frame-work built parallel to the railway track or cane platform and of sufficient height for the greater part of its length so that the cane may be dumped from the wagons or cars on to the carrier without elevating it. On approaching the wall of the mill house it gradually ascends and passes into the building at sufficient elevation to deliver the cane into the crusher or first mill rollers by an inclined chute, having a length greater than the length of the average stalk of cane. The highest point in the carrier is generally not over 6 meters from the ground level. The width is generally the same as the length of the mill rollers. The floor or belt of the carrier consists of two strong parellel chains, having a series of wooden or iron slats fastened between them so as to form a continuous belt of sufficient length to give plenty of slack on the return portion and avoid jamming

or breaking. The carrier belt runs on a series of rollers placed about two meters apart and closely resembling a small pair of car wheels mounted on an axle with the flanges on the outside. The flat link chain into which the ends of the slats are placed may run on the surface of these wheels or the slats themselves may come in direct contact with the wheels. When the slats are bolted to the chain it generally runs inside of the wheels and the slats may have protecting iron plates to avoid wearing at the point of contact. The return portion of the carrier platform is also supported on a series of wheels similar to those carrying the load on top of the carrier, but placed two or three times as far apart. Board or iron sides 30 to 50 centimeters in height are placed on both sides of the carrier so as to keep the cane on the moving platform.

Revolving knives.—Mills which do not use shredders are generally provided with revolving knives, mounted on a shaft and located at the highest point of the cane carrier and just in front of the crusher for the purpose of cutting off the projecting ends of crooked canes and those that get crosswise on the carrier. They also have a tendency to reduce the feed to a uniform depth in case it becomes piled up too thick at a given point.

Shredders.—A cane shredder is very similar to shredders and cutters used for the preparation of ensilage and corn stover. It consists in the main of a series of knives arranged in spiral form around a shaft or a series of disks, having double cutting edges, one of which is placed parallel with the axis of the shaft, the other vertical to it and so arranged that they form a spiral around the shaft. Cane shredders require to be much larger and stronger than corn shredders, as the work they do is much heavier and delays incident to breakdowns are very expensive. They are not used on mills having revolving knives and crushers and may be considered as more or less obsolete in modern sugar milling.

The crusher.—The best milling of sugar cane can be secured only when it is reduced to a fine state of division so that each particle more readily gives up the juice and sugar which it contains. This has led to the invention of a number of devices of which the cane crusher is the most satisfactory. There are three forms in common use but the best of these is undoubtedly the one known as the zigzag crusher. It consists of two heavy rollers, arranged one above the other in a very strong frame fitted with pressure springs or hydraulic jacks so as to keep the rollers in contact with each other, and generally arranged to be driven in connection with the mill rollers. The crusher rollers have high ridges made in a zigzag form and separated by deep groves so arranged that they mesh with each other like gear wheels. Another form has grooves cut around the circumference of one or both rollers, and sometimes longitudinal grooves are cut across these in order to make them take the feed

better. This form of crusher is known among the English manufacturers as a cane splitter and generally consists of two rollers like the zigzag crusher. This form of crusher has been made up by Louisiana planters as a modification of the first set of rollers in some of the older mills by simply grooving the top roller. The other form is known as the Diamond crusher. It may consist of two rollers both of which have a surface with diamond projections slightly elevated above the surface of the roller and so arranged that they mesh into each other, but a more common form is to replace the top roller of the first mill unit in modifying the six-roller mills without crushers so as to make the first set of rollers act as a crusher.

Whatever form of crushers is used the cane is delivered directly into it from the carrier and emerges from it after being reduced to a comparative state of fineness. With a good crusher it is practically impossible for any node or internode to pass through without being crushed, cut and split to such an extent that subsequent crushing is greatly facilitated. A crusher of this type when working well will extract from 50 to 55 per cent on the weight of the cane.

The mill.—The process of extracting the juice from sugar cane is one which requires a great deal of power and the use of high pressure. This necessitates building mills of such size and strength and fitting them for giving the cane a sufficient number of crushings before its final discharge that a profitable amount of the sugar which it contains may be recovered. The pressure required in the large mills is about 2 tons per centimeter length of roller, or about 300 tons on a set of rollers 1.50 meters in length. In order to withstand this heavy pressure the mill must be of a size much larger than the ordinary mills at present used in the Philippines. It is generally understood among modern sugar mill engineers that the length of the roller can not exceed twice the diameter in mills having rollers less than 80 centimeters in diameter. If mills are made of smaller size the length of the roller must be reduced much more than the diameter in order to maintain the necessary pressure for extracting the juice. Mills having a greater diameter of roller may have a length of slightly more than twice the diameter.

Large mills should be fitted with high pressure devices for securing as large an extraction of juice from the cane as possible. For this purpose the hydraulic pressure is decidedly the best, but springs, toggle joints, or wooden blocks may be used with a fair degree of satisfaction. The surface of the rollers of the cane mill should be grooved so as to enable it to take the feed readily. The common belief that some of the cane escapes pressure by getting into the grooves is not well founded. Sugar mills may have any number of rollers from three to eighteen, but are all made up of units of three rollers each. The most common number of rollers in the large plantation mills is either nine or twelve, and mill

engineers are in considerable doubt as to the economy of running larger combinations. A good twelve-roller mill will secure an extraction of 95 to 96.5 per cent of the sugar in the cane.

The crushed cane is delivered by gravity from the crusher rollers into the first mill unit where it is subjected to heavy pressure on passing between the top and the first bottom rollers. Then it passes over the trash turner which is a curved iron bed passing between the two bottom rollers. When it reaches the point of contact between the top roller and the second bottom roller it receives a second crushing. In mills having more than three rollers there is an intermediate carrier between each of the mill units which carries the crushed cane or bagasse upward and forward until it is delivered into the space between the top and first bottom rollers of the second mill, after which it receives two crushings as in the first unit. The same process is repeated for each unit and the cane may pass in succession from one mill unit to another as much as six times.

Maceration.—The extraction of the juice from cane is greatly facilitated by the application of water after it has been thoroughly crushed. Both hot and cold water have been advocated and many systems for its application have been devised, but the most common practice now is to apply all of the maceration water cold between the last two units of the mill, preferably just as the bagasse emerges from the rollers. This is generally done by maintaining a water pressure in a perforated pipe just behind the top roller of the mill unit next to the last. The amount of water to be applied varies from 15 to 40 per cent of the weight of the juice extracted from the cane and is dependent generally upon the fuel value of the bagasse. The juice extracted by the last mill consists largely of this maceration water with a very small percentage of sugar. This is run into a separate tank from which it is pumped back through another perforated pipe to the next unit which would be the first one in a nine-roller combination, or the second in a twelve-roller mill. This process is repeated for any larger combination thus concentrating the juice as it returns to each unit of the mill. The juice from the crusher and first unit is collected in a tank and known as first mill juice. The first and second mill juice are mixed before going to the clarifiers so that it is of a uniform composition.

Bagasse carrier.—After the bagasse passes through the last mill it is delivered into a receiving pit from which it is taken by a chain carrier either directly to the furnace room, or to another carrier which takes it to the stokers. In all modern mills bagasse contains an average of about 45 per cent of moisture and requires no further drying outside of the furnace before burning. The carrier passes above the furnaces which are fitted with a funnel-like stoker with a device for opening and closing a slot in the bed of the carrier by means of which the amount of bagasse

delivered into each stoker is regulated. The entire process of taking bagasse from the mill to the furnace room and firing the ovens is automatic and a large power plant requires only one or two attendants for regulating the water in the boilers, the fuel in the furnace, and watching the steam pressure.

Boilers.—Any type of boiler may be used but sugar mill engineers generally prefer the multi-tubular boiler in sizes furnishing about 200 horsepower. Considerable economy results in the fuel if the boilers are set tandem and the combustion furnace removed three or four meters from the first boiler.

Furnaces.—The furnace best adapted for burning bagasse is known as a Dutch oven type and fitted with a stepladder grate and automatic stoker. They are generally built of brick, stone, or concrete, and must be lined with fire brick, in order to stand the intense heat.

Mill engines.—The most common type of engine used for driving sugar mills is known as the slow-speed, high-duty engine of the Corliss type. They are made in sizes up to 750 horsepower and are connected with the sugar mill through the reducing gear arranged on a separate bed between the engine and the mill. It is always desirable to have plenty of power in a sugar mill as there is always a tendency to add to the work of the engine.

Juice pumps.—A sugar factory requires a great many pumps for a variety of purposes, especially the transferring of juice from one place to another as desired. For elevating it short distances centrifugal pumps similar to those used for irrigation purposes are commonly used but in smaller sizes. For pumping to high elevations where there is a heavy pressure the horizontal steam pump gives much more satisfactory results. These are made in a variety of sizes and combinations and are generally interchangeable for handling water and syrup.

Clarification.—Cane juice flows from the mill filled with a great many impurities. The trash is generally caught by the strainer but the juice flows into the receiving tank at the mill. It is then pumped to the liming tank usually located on the first or second floor of the mill building. After the tank is filled it is tested by the chemist who prescribes the amount of lime required for neutralizing the acidity in the juice. It should be stirred in the liming tank by forcing air or steam through it so as to insure a complete mixing of the lime with the juice.

Juice heaters.—While all modern mills use juice heaters, they are not essential. They are, however, very desirable and are but little more expensive than open tanks or clarifiers, fitted with steam pipes. The simplest form of juice heater consists of a boiler-like shell with heads and is fitted with drawn copper tubes in the same manner as a multitubular boiler. It has an inclosed space at both ends for admitting and discharging the juice and is fitted with steam pipes generally connecting

with the main shell outside of the tubes. There are in-take and discharge pipes for the juice connected with the open spaces in front of the heads. The juice is pumped in at one end of the heater, passes through the copper tubes where the temperature is raised to about 99°C., and emerges into the space at the opposite head from which it is taken to the settling tanks. There are other forms of juice heaters more complicated than this and particularly those with the superheater. This is a second heater placed on top of the first and so fitted as to raise the temperature of the juice above the boiling point. This superheated juice then flows back through the space which would otherwise be occupied by steam in simpler form and the heat it contains is absorbed by the cold juice just entering the heater, after which it is pumped to the settling tanks in the usual way. This combination is sometimes known as a superheater and an absorber.

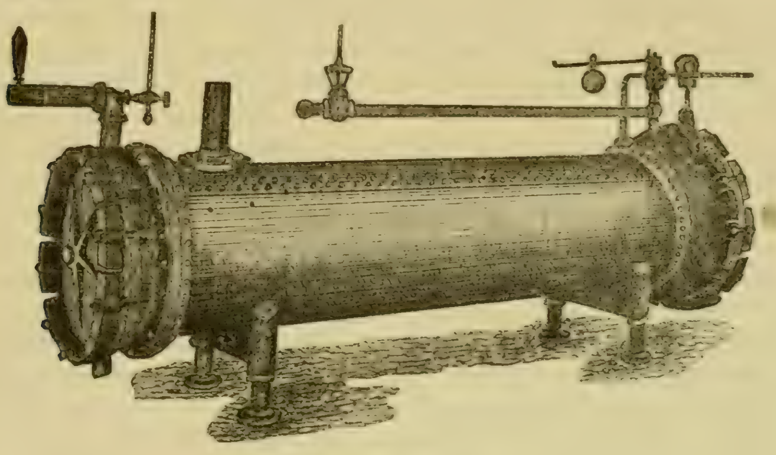


FIG. 14.—Juice heater. (Victor.)

From the heater the juice passes to the settling tanks for twenty or thirty minutes. If juice heaters are not used the juice goes directly from the liming tank to the settling tanks. The heavier sediment drops to the bottom, the scums come to the top, and the clear juice is drawn off from the center of each tank by means of a flexible pipe controlled by a float. When the clear juice has been drawn off until the scum approaches the sediment in the bottom of the tank it is indicated by the cloudy appearance of the juice which flows from the end of the pipe, which is then closed. A separate outlet is then opened in the bottom of the tank and the mud flows into a receiving tank near the filter press.

Filter press.—A filter press, as shown in the accompanying illustration consists of a series of iron plates and frames placed alternately on the main frame of the machine. The plates are corrugated and grooved or checked so as to leave as little surface exposed on the outer plane as

possible. There is a groove on each surface at the bottom which connects with an opening leading to the outside of the plate into which a small brass faucet is fitted for discharging the juice. The frames consist of an iron rim entirely open in the center. Both the plates and frames are fitted with openings at the top either in the center or at the sides. The more improved types have a series of openings at one side through which the juice is pumped and on the other through which steam or hot water is forced. It is fitted with a fixed plate at one end carrying water and steam connections and at the other with a very strong screw for holding the plates and frame in position when in use. The filter press is prepared for service by having a filter cloth folded in the center and placed over each frame, after which they are shoved together and the head plate connected with the screw is firmly pressed against them. The turbid juice with its mud and scum from the settling tanks is then pumped into the juice connection of the filter press and emerges through openings from the juice passage into each of the frames. The juice is forced by pressure through the filter cloth, trickles down the grooves in the plates and catches in a small gutter at the bottom and runs out through the faucet into the juice trough arranged along the side of the filter press. After the pumps have run sufficiently long the pressure runs up high enough to indicate that the frames are filled with the mud which constitutes the sediment deposited in the tanks. This is known as the press cake and often contains 5 to 6 per cent of sugar, the recovery of which is worth considerable expense on account of the great weight of the press cake from the large mills. This is accomplished by turning on steam or hot water through the opening in the opposite side of the press and forcing it through the press cake for some moments so as to dissolve out most of the sugar which it contains. The steam and juice are then turned off, the press opened up, the cakes dumped out for removal as a waste product and the filter cloths sent to the laundry. The filter press is again ready for work as soon as cleaned and refitted with clean filter cloths as before.

The sugar makers of the Philippines operating small mills find it very difficult to recover sugar from the scum and sediment although some of them claim that 10 per cent of the total sugar made can be recovered from this source, if sediments and scums are carefully worked.

Cake mill.—Large mills using irrigation water for the removal of the cake from the factory usually put in some form of burr-mill for the purpose of grinding the press cake so that it is readily washed away by the stream of water into which it is discharged. This machine is not necessary in mills using cart or rail transportation for the cake, which is generally dumped from the press directly into the vehicle or hopper from which it is subsequently loaded on to cars.

Multiple effects.—In all improved sugar milling the evaporation of the juice is accomplished by the use generally of double, triple, or quadruple effects specially made for this purpose. These consist of large closed iron bodies with arrangements for heating the contents and fitted with the necessary connections for admitting the juice and steam or hot vapor. The heating device consists of a steam belt placed inside of the body of the effect and resembles in construction a very short steam boiler with the multiple tubes arranged vertically. The steam connections pass through the body of the effect and into the space outside of the tubes in this steam belt. The juice occupies the space above and below the steam belt and inside of the vertical tube so that when the steam or hot vapor is admitted to the inside of the belt it heats the shell and tube and in turn raises the temperature of the juice. The top of the first effect consists of a vapor dome and tube which passes down and connects with the steam or vapor belt in the next effect, and the top of this one is again connected with the third and the third with the fourth in quadruple effects. When there are two bodies in an evaporating set it is known as a double effect, three is a triple effect and four is a quadruple effect. The vapor pipe of the last effect is a little more than 10 meters in length, is connected with a vacuum pump and the foot of the pipe is immersed in a water tank known as the hot well. When the multiple effect is in operation the vacuum pump is kept constantly running so as to maintain a vacuum of about 710 millimeters in the second, third, or fourth effect, according to the number of bodies used, and decreases in each succeeding effect back to the first one where there may be only a slight vacuum or even a little pressure. The vapor arising from the surface of the boiling sirup in the last effect comes into contact with a stream of cold water passing through the vapor dome at the top of the water-leg, is condensed and passes down the pipe as water.

These multiple effects are operated by pumping the juice into the body of the first effect and admitting exhaust steam from the engine into the steam belt which heats the juice surrounding it. This effect may be worked with a slight vacuum or pressure depending on fuel supply. As soon as the juice has reached a high enough temperature it begins to give off vapor which passes over through the vapor pipe into the vapor belt of the next effect. The juice or thin sirup which this effect contains is in turn heated by this vapor and boils at a lower temperature than the contents of the first effect because of the higher degree of vacuum. The vapor which it gives off is in turn passed on to the vapor drum of the third effect where there is a still higher vacuum and the heat contents of the vapor are sufficient to boil the sirup in this effect. The vapor again passes over to the fourth body in the quadruple effect where the

vacuum is constantly maintained at about 635 to 710 millimeters and the contents are easily boiled at very low temperature.

The juice passes in succession from the first effect through to the last one of the series and is gradually concentrated into it and emerges in the form of a sirup of medium density, after which it is pumped into the sirup storage tanks and held in readiness for final evaporation into sugar in the vacuum pan.

Vacuum pans.—The vacuum pan is similar in construction to a single body of the multiple effects but is provided with a larger heating surface and a better system of regulating the temperature and vacuum. It is provided with a water leg ending in a hot well and connected with a vacuum pump arranged the same as for the last body in a multiple effect. They vary in size from a capacity of 1 to 50 tons of massecuite. It is fitted with a device known as a proof-stick for taking samples of the contents while being boiled. There are also gauges for determining the height of the liquid in the body and they are sometimes fitted with sight glasses for watching the contents while boiling. The most common arrangement for heating the vacuum pan is by the installation of coils of copper pipe running horizontally around the inside of the body up as much as half way to the top of the pan and each coil so connected that steam can be turned into it separately. This arrangement permits the introduction of a small amount of sirup into the bottom of the pan so that it can be rapidly concentrated to the point where the sugar in it will begin to crystallize, after which additional juice can be admitted from time to time and more heat turned on until the pan is entirely filled with the crystalline mass mixed with a small portion of sirup and forming what sugar boilers term "massecuite." When it reaches this condition it is ready for a strike which consists of turning off the steam, admitting air into the body of the vacuum pan, and opening the large valve at the bottom so that the entire contents are delivered into the sugar cars, mixers, or crystallizers, depending on the system used.

Another arrangement for the heating of vacuum pans is known as the "express system" in which the coils of copper pipe are displaced with a steam belt composed of a large drum both surfaces of which slope to the center of the pan where there is a large opening immediately above the door in the bottom through which the sugar is discharged. The tubes pass from the upper to the lower surfaces at an angle with the walls of the pan. When the heated liquid in these tubes begins to rise it passes toward the center of the body, rises, and goes to the outside where it descends until it reaches the under surface and is again forced through the tubes toward the center. This system is said to give a much better circulation and more economical evaporation of

the sirup than the standard copper coil heating arrangement ordinarily used in vacuum pans.

The use of exhaust steam.—Sugar-mill engines are generally of the high-pressure type and the exhaust steam is used for all heating purposes

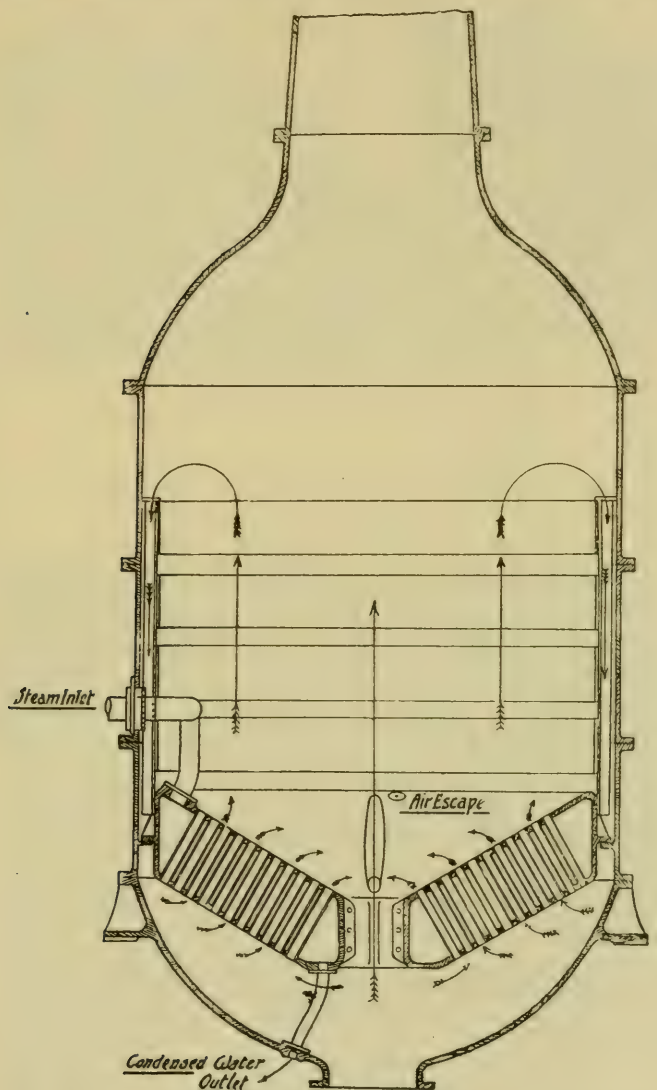


FIG. 15.—Body of vacuum pan showing the express system of evaporation.

in the factory, especially for the evaporation of the juice in the multiple effects and the sirup in the vacuum pans. It is also used for stirring and heating the juice in the liming tanks, in the clarifiers or juice heaters, for melting the second and other low grade sugars, and other

general heating purposes throughout the factory. The water of condensation secured from this steam after it is used for the purposes named is pumped back to the boiler feed tanks and again used for boiler supply. One of the difficulties in the repeated use of this water after passing through the mill engines is that it contains oil and other impurities which become mixed with it on passing through the engines, pipe lines, and steam belts where it is used. Where water is scarce that evaporated from the juice in the multiple effects and vacuum pans can also be used for boiler supply, but often contains impurities which make it undesirable.

Crystallizers.—After the massecuite has been discharged from the vacuum pan it may be handled in a number of ways, but most of the modern mills place it in closed crystallizers equipped with a stirring device for keeping it in motion during the period of a few hours or even for several days where the sugar being manufactured is of low grade. This stirring aids in the building up of the sugar crystals by any additional crystallizable sugar which may remain in the massecuite and keeps the material in a semifluid state so that it will flow into the centrifugals for purification.

Where closed crystallizers are not used the massecuite is often placed in open mixers which may or may not be provided with stirring devices similar to crystallizers. In the smaller mills this mixer is generally placed just above the centrifugals and so arranged that the contents may be emptied directly into the crystallizer baskets. Some of the older mills, especially of the smaller capacities, have neither of these but use a small tank car or truck sometimes called "coolers." Enough of these should be provided to store the entire contents of the vacuum pans in use and have a surplus to avoid congestion in case any accident happens to the centrifugals.

Centrifugals.—Sugar centrifugals are an essential part of modern milling equipment. These machines are made singly or in batteries of from two to eight arranged in continuous iron frames with the necessary supports and connections for their operation. The simplest form is driven by a belt to each machine, though there is a tendency to drive them by water or by electric motors. The essential working part of a centrifugal is an iron basket 76 to 102 centimeters in diameter suspended on a vertical shaft at the top of which the driving arrangement is attached. There is a large opening in the bottom of the basket which is closed during operation by a conical steel cover fitting around the shaft. There is also a receiving trough in the bed of the machine just under the basket into which the molasses thrown out of the sugar catches and flows away to the molasses tank. The operation of these centrifugals is quite simple and consist in placing 100 to 200 kilos of massecuite in the basket after which it is set in motion and the centrifugal force

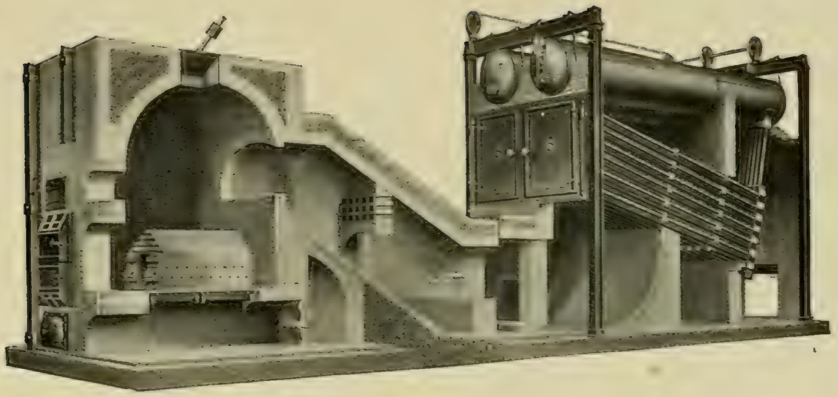


Fig. 1.—WATER-TUBE BOILER, WITH PATENT BAGASSE FURNACE. (Babcock & Wilcox.)

Fig. 2.—VIEW OF FURNACE ROOM SHOWING AUTOMATIC BAGASSE CARRIERS AND STOKERS. (Honolulu Iron Works.)

PLATE XVII.

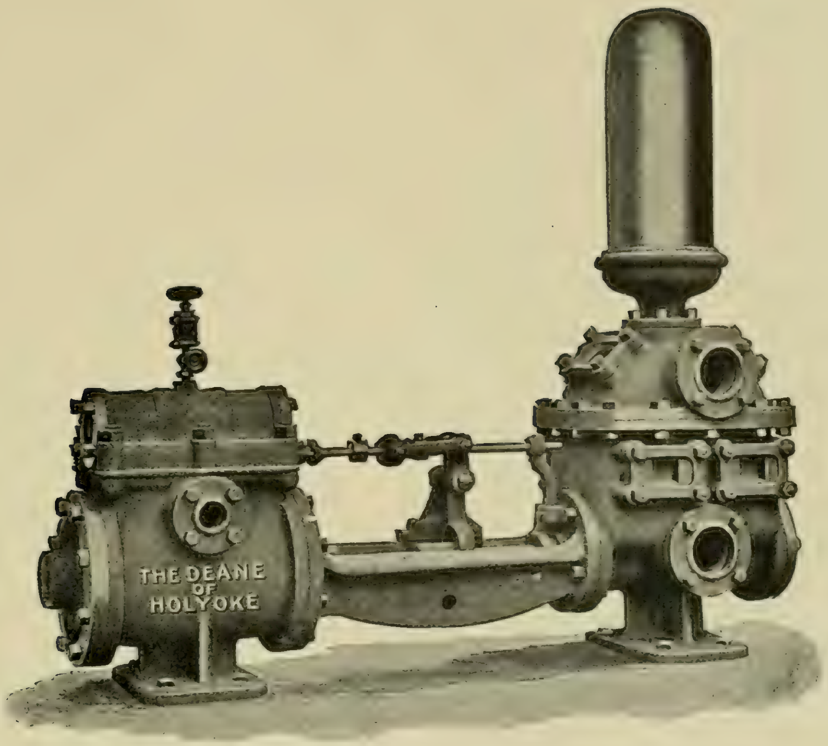


Fig. 1.—GENERAL SERVICE PUMP FOR JUICE, SIRUP AND WATER. (Deane.)

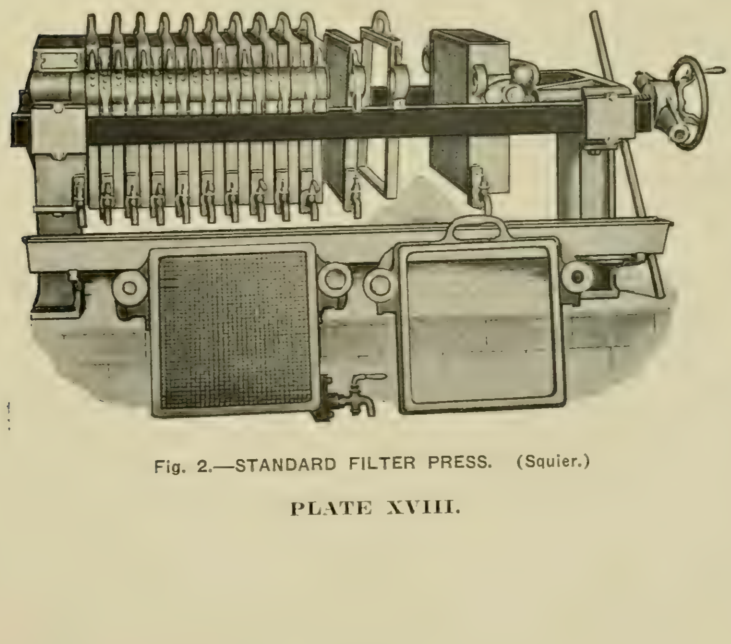


Fig. 2.—STANDARD FILTER PRESS. (Squier.)

PLATE XVIII.

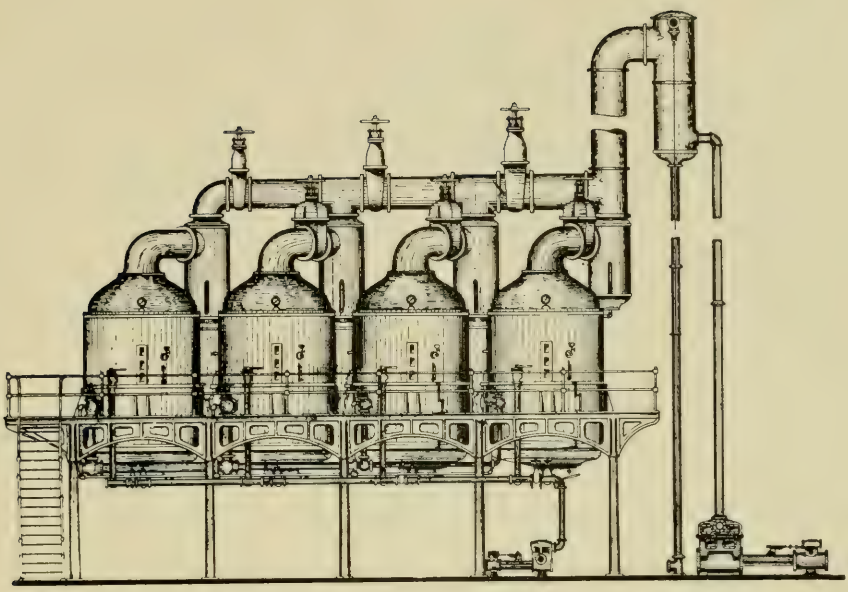


Fig. 1.—STANDARD QUADRUPLE EFFECT. (Honolulu Iron Works.)

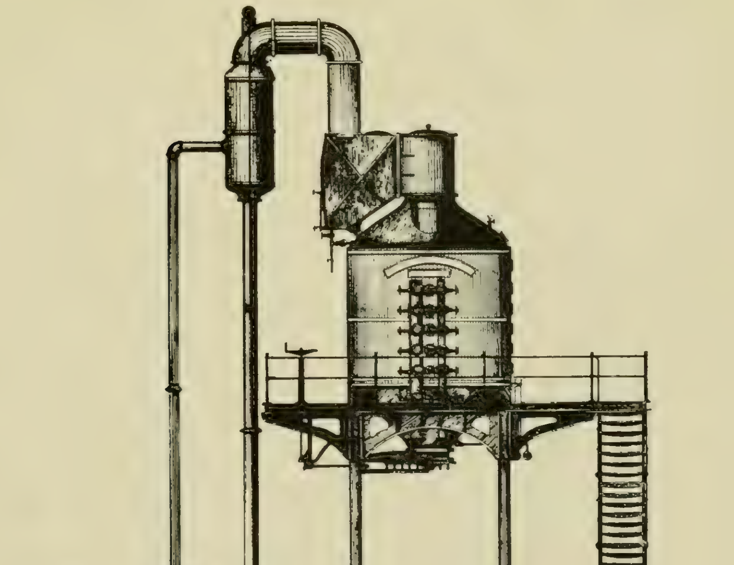


Fig. 2.—STANDARD VACUUM PANS. (Honolulu Iron Works.)

PLATE XIX.

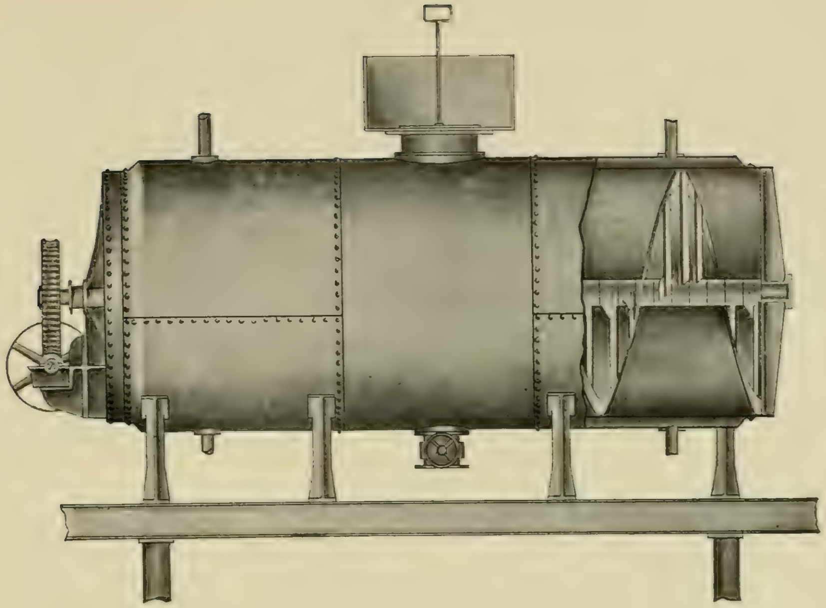


Fig. 1.—CLOSED CRYSTALLIZER WITH SPIRAL MIXER. (Payne & Joubert.)

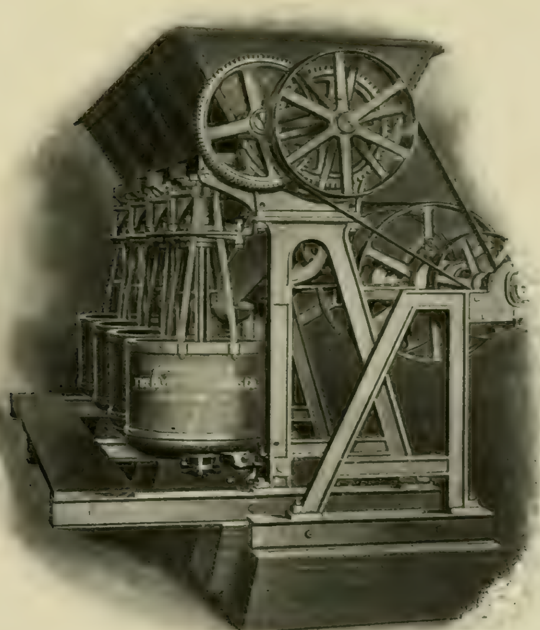


Fig. 2.—BATTERY OF BELT-DRIVEN CENTRIFUGALS WITH OPEN MIXER. (Blymyer.)

PLATE XX.

Fig. 1.—OLD SPANISH SUGAR MILL, LA GRANJA MODELO, OCCIDENTAL NEGROS.

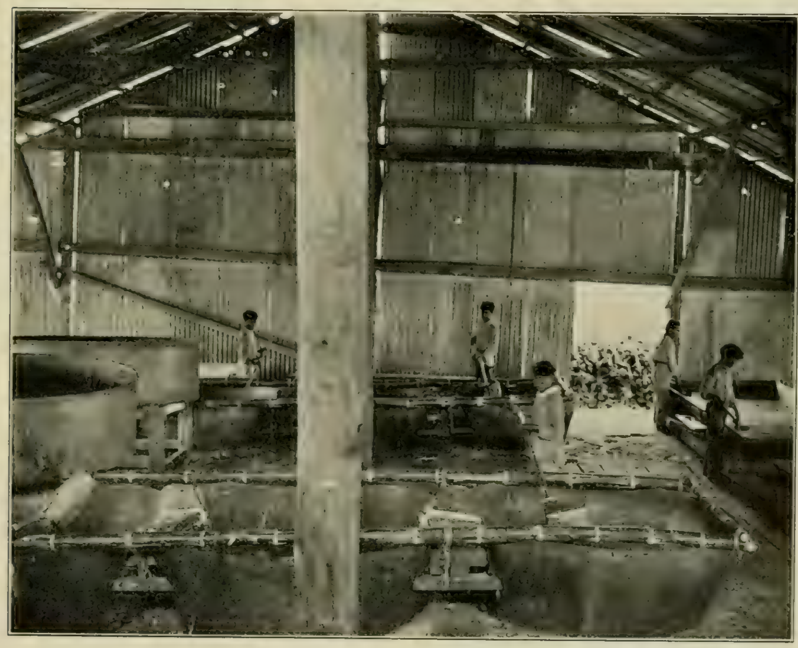


Fig. 2.—INTERIOR VIEW OF SAME MILL, SHOWING SETTLING TANKS, JAMAICA TRAINS, AND COOLERS.

PLATE XXI.

thereby generated draws out most of the sirup through the fine perforations in the wall of the basket. It is further purified by throwing a fine spray of water on the sugar contained in the basket while in motion, the degree of washing depending largely upon the grade of sugar which it is desired to make at a given time.

The sugar made directly from the evaporation of juice is known as "first sugar" and when the molasses from the centrifugals is reboiled to secure further crystallization of the sugar content it is known as "second sugar" and the sirup from this as "third sugar," and so on for the lower grades.

Centrifugals can not be used on concrete sugars manufactured in open kettles in the Philippines as it is ordinarily delivered from the caldrons.

Driers.—After leaving the centrifugals sugar contains from 1 to 5 per cent of moisture depending on the grade, the amount of washing and climatic conditions. The higher grades such as "plantation granulated," manufactured for direct sale to the consumer, contains only about 1.5 per cent of moisture but must be thoroughly dried in order to reach the consumer in satisfactory condition. For this purpose many forms of driers have been devised, but most factories now use the rotary drier, heated by a large steam coil placed in an inclosed room at the end of the drier and so arranged that air can be forced over the heated pipes into the revolving shell of the drier through which the sugar passes in the opposite direction. After emerging from the drier the sugar is taken to the storage bins from which it is delivered into the bags ready for shipment.

Bagging.—The standard grades of sugar should be packed in uniform jute bags of convenient size (50 kilos) for handling. The higher grades, such as "plantation granulated" just mentioned, should be placed in double bags, the inner of which is made of white cotton cloth and generally sewed separately from the outer jute bag.

Storage.—Where sugar is to be held at the factory for any considerable time good warehouses should be provided so that it may be stored in a manner which will avoid deterioration or loss. It should never be placed directly on cement floors or against stone walls where there is a tendency for moisture to accumulate.

Shipping.—Most modern sugar mills are provided with shipping facilities immediately connected with the mill building. This generally consists of a railway track running under a shed ajoining the bagging room and warehouse. The sugar is loaded directly into the cars by hand or special bag conveyors, according to the equipment in use. Mills located on navigable streams or other waters often have docks at the mill or very near it so that the sugar may be loaded directly into the boats or some other form of water craft, which conveys it to the larger vessels in which it is shipped to the regular markets.

CHEMICAL CONTROL.

Chemical laboratory.—All modern sugar mills should have a good chemical laboratory equipped with all the apparatus and supplies required in the preparation and analyses of all sugar-house products. It is very important to know the exact composition of the cane at the time of entering the mill, percentage of juice and sugar extracted from it, the composition and reaction of the juice, the degree of density of the sirup made in the multiple effects, and the amount and quality of sugar finally delivered from the centrifugals. In a factory turning out a hundred tons of sugar a day a decrease of 1 per cent in the extraction secured by the mill would mean a decrease of 1 ton of sugar, worth at least ₱150. The only way to find such losses is by constant observation and thorough analyses of all the sugar-house products.

The sugar chemist.—Sugar chemistry is recognized as a special branch of chemical science as applied to manufactures. The preparation and work involved are common to many other branches of laboratory work, but the men who conduct the chemical control of sugar mills must specialize in this branch of chemistry and generally do not carry on any other work at the same time. The necessity for the service of sugar chemists is constantly increasing as investors in the growing and manufacture of sugar are coming to realize more fully that an exact knowledge of the many processes involved is necessary to an intelligent handling of the sugar-manufacturing plant.

Sugar laboratory at Iloilo.—The Government of the Philippine Islands has recognized the importance of the sugar chemist and his work, by the establishment of a sugar laboratory at Iloilo in charge of the Bureau of Science. This was the first institution of its kind in the Philippines and until very recently it did not meet with popular favor among sugar growers and buyers. However, it has demonstrated its usefulness so fully that the most important sugar sales are now made on the basis of official polarizations secured from this laboratory.

Composition of Philippine sugars.—The following analyses of Philippine sugars were made by Mr. H. Pellet[1] from samples furnished by Mr. C. A. Brown, Ph. D., chemist of the New York Sugar Trade Laboratory:

Philippine mat sugar.

Grade.	Water.	Polarization.	Reducing sugars.	Ash.	Organic matter.	Total.	Character and color of crystals.	Reaction.	Commercial rendement.
No. 1	1.94	88.20	3.90	1.53	4.43	100.00	Sandy, yellow	Alkaline	74.28
No. 2	2.16	85.30	5.70	1.64	5.20	100.00	do	do	67.34
No. 3	2.14	82.90	6.90	2.00	6.06	100.00	Sandy, brown	do	61.10

[1] International Sugar Journal (Altrincham), vol. 13, No. 150, June, 1911.

For purposes of comparison of the composition of these sugars with those produced in other countries the following analyses are given:

Standard grades from other countries.

	Water.	Polarization.	Reducing sugars.	Ash.	Organic matter.	Total.	Character and color of crystals.	Reaction.	Commercial rendement.
Java basket sugar	0.26	97.75	0.55	0.48	0.96	100.00	Loose, grayish	Alkaline	94.73
Hawaiian centrifugal	0.74	96.50	0.90	0.58	1.28	100.00	Small, loose, grayish.	do	92.38
Cuban centrifugal	1.46	96.20	0.52	0.90	0.92	100.00	Medium sized gray.	Very alkaline.	91.56
Porto Rican centrifugal	1.30	94.70	1.50	0.68	1.82	100.00	Medium sized, yellow.	Slightly alkaline.	88 98

SUGAR-CANE PESTS.

By O. W. Barrett, *Chief, Division of Experiment Stations,*

AND

D. B. Mackie, *Agricultural Inspector.*

While most cane-producing countries of the world suffer more or less severely from fungi and insects, the Philippines are practically exempt from such damages. There are, of course, a few blights and fungus troubles, especially in the rainy season, and in some districts there are rather severe damages occasionally from locusts, rats, wild pigs, monkeys, and the cane root beetle.

The only pests worth serious consideration at present by the Philippine cane growers are, in order of importance, as follows:

1. Rats.	4. Monkeys.	7. Tip borer.
2. Locusts.	5. Cane root beetle.	8. Cane fly.
3. Wild pigs.	6. Cane weevil.	9. White leaf louse.

MAMMALIAN PESTS.

Rats.—This pest seems to be confined almost entirely to the Island of Luzon, though a few districts in the Visayas and the Island of Marinduque are reported as suffering more or less in some seasons. On the Island of Luzon the heaviest infestation seems to be in the sugar belt of Pampanga and the contiguous provinces. The species responsible for most of the damage are *Mus rattus, M. alexandrinus,* and *M. norvegicus;* these species are all more or less brownish in color and vary from gray to whitish underneath, mature individuals measuring from 330 to 350 millimeters. As in other countries, damage by rats in Luzon is not so much due to the amount of canes actually eaten by the rats themselves as to the danger from entry of secondary fungi and insect pests into the more or less slightly gnawed canes. The red cane weevil (*Sphenophorus* sp.) is attracted to the injured cane, and various bacteria and fungi find a suitable field for their operations therein; in fact, after a cane is damaged merely in one place it is practically certain that the entire cane will become not only worthless, but if ground with the other canes it would probably cause a considerable amount of reduction or inversion in the juice by reason of its fermented sap.

The rats being comparatively unmolested by both mongoose and snakes have acquired the habit of making their nests in the trash about cane roots in the plantations. It appears that there are two broods per year and about three or four individuals in each brood. Though there is more or less difficulty in dealing with this pest it is certain that arsenic, if properly applied, will greatly reduce their numbers; the seriousness of the pest would be mitigated in a great degree were the planter to attend to this matter immediately upon noticing the effects in the plantation. Strychnine has also been used in some cases; and a cheap variety of wire-spring trap (costing some 20 centavos) may be used successfully on some plantations.

In dealing with this pest, either by poisons or traps, ordinary observation will disclose certain weak points, so to speak, in the life history of the pest; for instance most rats use paths or runways in going to and from their nests in the fields, and it is along these runways that the traps or poisoned bait should be placed.

A formula for poisoned bait, which has given excellent results in the experiments by the Bureau of Agriculture, is made by simply mixing about 5 per cent (by weight) of common powdered arsenic with some food of which the rats are fond, such as ground coconut "meat," sweet potatoes, or corn meal. If corn meal be used it is necessary to boil the meal until it is of the consistency of a thick mush, after which the arsenic should be thoroughly mixed in. Barium carbonate is said to give the same results if used in the same way as arsenic, but arsenic is certainly a more popular poison for this work. Strychnine is very effective under favorable conditions but its use is always attended with considerable difficulty on account of its exceedingly bitter taste. If the rats can be induced to eat some bait, such as camotes or chopped-up coconut, containing even a small amount of strychnine sulphate, the result may be better than with arsenic; a small amount of raw sugar mixed with the bait is said to overcome, in a measure, the bitterness which would otherwise, perhaps, prevent its being devoured by the rats.

If the rats in the cane plantation have the habit of burrowing into the ground, a direct method of eradicating the pest may be employed: The rats frightened into their burrows, may be killed therein by simply inserting about a tablespoonful of carbon bisulphide (preferably applied on a small handful of crushed cane trash) and immediately stopping the mouth of the burrow with earth; if the burrow has no other opening the rats will be immediately overcome by the poisonous gas. This bisulphide method is particularly recommended for use in young cane where the rats are forced to make retreats below the surface of the ground.

Wild pigs (*Sus philippinensis*).—Wild pigs are common in nearly all sections of the Archipelago where there is sufficient forest or jungle growth to furnish them adequate protection. Any cane field located

near a patch of forest, therefore, is very liable to nightly attacks by these animals and the damage done in some districts is very considerable. As with the rats the actual amount of cane eaten by the pigs is a small matter compared to the amount trampled and partly broken down. It is said that during the rutting season of the males they frequently enter cane plantations, trample, break, and chew the cane, apparently desirous of doing as much damage as possible.

Obviously the only remedies for this pest to be recommended are a woven-wire fence (which is usually impracticable) and the liberal use of dogs and rifles. This Bureau has conducted experiments with cyanide of potassium which have demonstrated the fact that in the hands of an experienced person this poison is decidedly effective.

Monkeys.—The common monkey (*Macacus rhesus philippinensis*) is responsible for the loss of no small amount of sugar cane in certain districts. In the southern part of the Island of Negros, sugar planters are sometimes obliged to keep a man on watch to scare them away. They are exceedingly cunning and it is almost impossible to poison or trap them, but they soon learn to keep their distance if shot at, especially if a dead one can be hung up in plain view.

INSECT PESTS.

Locusts.—Although these insects are not strictly cane pests there are numerous cases of very great damage resulting from both flying swarms and the young insects. The two principal species in the Philippines are *Acridium migratorium* and *A. manilense.* In case of the adult or flying insect but little can be done beyond trying to prevent a swarm alighting in the field; smudges made with dampened cane trash, rice straw, etc., or a loud noise made by beating on tins or bamboos are often successful, if sufficient warning is had of the approach of the swarms.

During the "hopper" stage (loctones) excellent results may be had by spraying some arsenical preparation onto the herbage just ahead of the moving swarm. Any of the arsenical compounds, such as arsenate of soda, arsenate of lead, or arsenate of copper (Paris green) may be used. The best results will be obtained by applying the poison about 4 or 5 o'clock in the afternoon, at which time the insects begin to stop to feed and rest. If the spray is properly distributed a little in advance of the slowly moving swarm, the foremost insects will immediately stop to partake of the sweetened mixture, and, becoming at once affected thereby, will be promptly attacked and devoured alive by succeeding individuals; by reason of this cannibalistic trait the poison is made effective through two and even three successive individuals—i. e., theoretically, one "hopper," having gorged himself with the poisoned food, will virtually *kill up to six others*—two "hoppers" usually devouring the body of each victim.

The entire swarm should be killed by one application if the latter be properly distributed in the right place at the right time.

Arsenate of soda and Paris green should not be used on any of the cultivated crops, as the arsenate, being in a more or less soluble condition, will be absorbed into the plant tissues, thereby causing their death. For cultivated crops *arsenate of lead* can be used without danger from this source, as the poison is merely in suspension and will not interfere with the growth of the plants.

In the case of arsenate of soda, 1 kilo to 100 liters of water will usually prove of sufficient strength; for asenate of lead, 1 kilo to about 80 liters of water; and for Paris green, 1 kilo to about 300 liters of water should be used. In preparing these compounds if a certain amount of cane juice (in place of the water) or molasses is added, the poisoned foliage will be much more readily eaten by the locusts.

While under ordinary conditions, it is, perhaps, inadvisable to spray standing cane, it may be possible with the modern improved nozzles to treat cane during any stage of growth.

Great care should be taken to prevent domestic animals from feeding upon vegetation of any kind sprayed by any of the arsenical mixtures.

The most popular method is driving the "hoppers" by means of beaters working from behind and a line of galvanized-iron sheets along the sides of the swarm; the driving method is the only one heretofore used by the provincial planters. The insects driven from the field into a deep trench may be easily killed and used as fertilizer. In South Africa they are used extensively dried, as feed for poultry, pigs, and even mules.

Mature cane is, of course, not entirely ruined by the attack of these insects, but if the field be very young it may be quite destroyed during one night by a passing swarm.

Extensive loss from locusts in the Philippines need not be anticipated, as at present the laws in vogue make the destruction of locusts compulsory and place a heavy fine on any violation thereof.

Cane-root beetle, or *Buc-an* (*Holotrichia vidua* Sharp. Melolonthidæ).—This pest is probably present throughout the Archipelago, but in nearly all cases is not sufficiently abundant to render strong measures necessary for its treatment. The mature beetles fly in April and May, at least in the Visayas. They are large, brown insects closely resembling the May beetles of the United States; they fly only at night or toward evening on cloudy afternoons. The large white grubs or larvæ may be noticed in plowing infested fields; and frequent plowing is probably the best method of eradicating the pest, since the grubs are eagerly sought after by crows and other birds, flocks of which are usually seen about fields being plowed. The larvæ feed upon the root and base of the stalk which, of course, causes the plant to turn yellow and

frequently die. Since the life cycle occupies something over a year the damage is wrought at no particular season. Although the life history is not yet thoroughly worked out, it is certain that the larva at the completion of its stage of growth hollows out a chamber of sufficient size among the larger roots and stalk bases, using the frass to form a sort of coarse cocoon in which it undergoes the comparatively brief pupal stage.

The adult beetles seem to be strongly attracted to the "gauigaui" trees (*Sesbania grandiflora*) and in some districts immense numbers of them may be seen or heard flying about these trees in the evening. Fortunately this pest is attracted to strong lights and, therefore, it may be successfully combated by the use of trap lights placed in or near the cane field. These lights should be raised a meter or more from the ground and underneath each light there should be placed a pan as broad as possible containing water and a small quantity of petroleum. Any large or brightly burning lantern will suffice; generally speaking, the stronger the light the greater will be the number of beetles caught in the pans.

One of the principal causes of the prevalence of these insects in certain districts is the practice of leaving the stubble in the ground for several seasons. Any field believed to be infested with this pest should be plowed and thoroughly harrowed as often as possible, the roots of the old canes being removed from the soil and burned. The use of animal manures should also be avoided as these undoubtedly attract the mature insects when about to deposit their eggs.

It is said that applications of kainit or other potash compounds will kill or drive away grubs from the cane roots.

Tip borer (*Scirpophaga intacta* Snell. Pyralidæ).—This small white grub, usually entering near the tip of the cane, is the larva of a small white moth having a tuft of brownish hair on the underside of the abdomen. The eggs are laid on the leaves near the top of the canes and are covered by a mass of cinnamon-colored hair which is rubbed from the abdomen and plastered over the egg mass, thus protecting the eggs more or less from enemies and water. The larvæ when hatched bore through the rolled-up leaves and eat their way downward through the stem, often going through two or three joints. After attaining its full size it eats its way through the rind of the cane and after spinning a web across the entrance to its burrow it finally attaches itself to the wall of its chamber by fine silky threads and there undergoes the pupal stage. It may be that this species is a variety of *S. auriflua* Zell., the only difference being that in the before-mentioned species the fringe of hair is brown while in the latter one it is buff in color. The moths may be noticed during the daytime resting on the underside of the leaves

while at night or in the early part of the evening they may be seen hovering over the canes. The life cycle is completed within forty-eight to fifty-six days, this time being divided as follows:

	Days.
Egg	8 to 9
Larva	82 to 35
Pupa	8 to 12

To be added to this, however, are the few days (five to ten) which the moths spend in mating and laying their eggs.

Canes attacked by this insect may be recognized from a tendency of the leaves to become "bunchy" at the apex of the stalk; on account of the shortening of the joints, the leaves and shoots often have a fan-like appearance. These very conspicuous canes should be cut out both as a remedial measure against the pest and because the sugar content of the affected canes is greatly reduced by the strain of producing an abnormal number of sucker-like shoots. These tops can be fed to cattle and in this way there is little or no loss to the fields.

These moths are attracted to strong lights and may be destroyed in large numbers by the same method as that recommended for trapping the root beetle.

Leaf louse (*Oregma lanigera.* Aphidæ).—This insect, although of general distribution, is of comparatively little importance as a cane pest in the Philippines. Cane leaves attacked by this louse have the appearance of being covered with a white cottony substance. It would seem that only weak plants are attacked by this pest though it might, under favorable conditions, spread extensively and cause considerable damage. Canes infested with this insect sooner or later turn yellow, and of course, do not contain the normal amount of sugar. A large species of *Coccinellidae* feeds upon these insects and it is not uncommon to find a large percentage of a colony destroyed by this beetle.

Cane fly (*Phenice moesta* Westw. Fulgoridæ).—These small black-and-white insects are not flies, but belong to the family of bugs and are related to the famous lantern-flies of tropical America and to the leaf-hopper which does such extensive damage in Hawaii. In the Philippines they seem to be of local distribution and of little economic importance. However, large colonies are sometimes found on single plants or over a limited area of a plantation.

If present in large enough numbers to warrant, a weak spray of kerosene emulsion would probably suffice to exterminate the pest.

It is not improbable that there are other pests than those above mentioned which attack sugar cane in the Philippines, yet if such are present they are of minor importance as evidenced by the fact that during the past decade this Bureau has not had its attention called thereto.

FUNGUS DISEASES.

On the whole the cane plantations of the Archipelago seem to be remarkably free from attacks of fungus parasites. The red rot caused by *Colletotrichum falcatum* has been reported in the Philippines, yet, according to the botanist of the Bureau of Science, no specimens of this particular fungus have ever been secured for that Bureau's collections and it is doubtful whether it actually exists here.

Bacteria and possibly several saprophytic fungi enter wounds made by rats, pigs, root-borers, stem-borers. and even through the punctures made by the wooly aphis and the cane flies; but such fungi are, of course, only secondary parasites and could not exist without the primaries.

A kind of blight was discovered last season in Occidental Negros which has been reported as probably a new species, and cane leaves apparently attacked by the eye-spot disease (*Cercospora sacchari*) have been noted by Mr. Elmer D. Merrill, botanist of the Bureau of Science; but this disease which causes severe damages in other countries is of very little importance here.

THE GUANICA CENTRAL, PORTO RICO.[1]

Guanica Central Factory, which is the property of the South Porto Rico Sugar Company, is situated on the southern side of that island, and its operations extend from Mayaguez, on the western side, to Amelia, an estate about 10 miles east of Ponce, on the eastern side; that is, a distance of about 80 miles. The factory is near the middle of the district, being 40 miles from Mayaguez and 40 miles from Amelia. The canes are taken to the factory mainly by the American Railway Company's line; in addition, the South Porto Rico Sugar Company possesses about 13 miles of a similar gauge (1 meter) to that of the American Railway Company.

On each estate are loading stations at which the canes are weighed; they are taken to the loading stations by trucks drawn by oxen, running on permanent and portable tram lines, and by ox carts. Each cane wagon holds from 15 to 18 tons of clean canes, and is divided into two compartments. During the day and night, Sunday included when necessary, these wagons are collected and taken to the factory by the railway engines. On the funnels of these engines a special form of mushroom-shaped spark-arrester is attached, to prevent the ignition by sparks of the fields of sugar cane along the line. Some of these engines take to the factory at one time as many as 450 tons of cane. At the factory a small locomotive is kept for removing the empty wagons and putting filled ones into their places.

In addition to a number of estates belonging to the company and leased by it, from which something like 1,000 acres is cropped, canes are purchased from independent growers, known as colonos, or, as they would be termed in the British West Indian Islands, cane farmers. These colonos, as well as the estates which are worked separately from the factory, are credited with from 5½ to 6 per cent of the weight of the sugar extracted from the canes, according to the quality of the juice. and paid for on its value in the New York market at the time of its manufacture.

The wagons containing the canes are drawn one at a time into the mill house by a cable attached to a drum of an electric winch. Chains suspended from a strong beam are passed along the inside of the wagons,

[1] From the International Sugar Journal, vol. 13, No. 149, May, 1911.

across the bottoms under the canes and hitched at the side. The canes are then hoisted by an electric winch attached to a traveling crane suspended over the wagon. While it is thus suspended, the weight of each half carload is recorded automatically on a ticket inserted into a slot in the weighing machine. The crane is then run over a hopper, and discharged by means of a lever which liberates the hitches in the chains. Along one side of the hopper an elevator, having curved iron rods on it, takes the canes to the crusher before the mill. There are four of these mills, and for the purpose of keeping an accurate account of their work, extraction, etc., they are designated A, B, C, and D. A is a Fulton Ironworks Cora, 78-inch by 34-inch twelve-roller mill, with crusher. B is a 72-inch by 37-inch six-roller mill, with crusher; it is only used when more canes are received than the three other mills can crush. C is an 84-inch by 34-inch twelve-roller mill, with crusher; and D is a duplicate of A, that is, a Fulton Ironworks Cora, 78-inch by 34-inch twelve-roller mill, with crusher. All the mills have hydraulic pressure, acting on the top rollers. Water is used for maceration before the feed rollers of the second, third, and fourth mills, and amounts, on the average, to 20 per cent of the weight of the juice.

The extraction of the juice in the canes, under these conditions, when the six-roller mill was not in use, was from 84 to 86 per cent of the weight of the canes. The mixed juice from the mills passes through what is called a double-decked strainer. Along the surface of each strainer a scraper elevator runs, removing the particles of fine megass, etc., and dumping them on the megass between the second and third mills. From the end of the strainer the juice is sent by a bucket elevator to eight weighing tanks, which are six feet in diameter and contain, on the average, about 4,000 pounds of juice. In order that an accurate check may be kept on the results of the crushing of the mills, the tanks are filled with water and weighed daily, so as to ascertain that the scales are recording correctly. The cane scales are also checked every day by means of an unused mill roller of known weight, which is kept on a truck, so that it may be run beneath each scale and weighed. Analyses are being made continually, and every morning the head of each department makes a return to the general manager of the result of the previous twenty-four hours' working, so that at the beginning of each day that officer has in his possession the weight of the canes, the weight of the juice and the average analyses of the juice and megass made every four hours for the past twenty-four hours; he can therefore see at a glance whether the mills are extracting the highest possible quantity of juice from the canes, and is in possession of other useful information necessary to the provision of complete control.

Toward the end of the last reaping season, as an experiment, the megass from one of the twelve-roller mills was macerated and passed

through the last three rollers of the adjoining mill, and an extra 2 per cent on the weight of the cane, in juice, was obtained. In consequence of this, the company, which has recently purchased the Fortuna factory, is at present installing there a fifteen-roller mill, with crusher. It may be mentioned here that at Fortuna factory the Naudet process was formerly in use, but the machinery for this is now being discarded so as to make room for ordinary multiple mills.

From the weighing tanks, the mixed juice is pumped to the liming tanks. On its way to these, milk of lime is run in at the rate of 1 pound of lime to 1 ton of canes, and by means of a small pump a stream of the limed juice passes in an open gutter in front of an operator, who with a solution of phenolphthalein, contained in a large glass receiver, ascertains whether the juice is sufficiently limed, by dropping a small quantity of the indicator into the limed juice as it passes before him. In the event of the juice needing more lime, by opening a cock he increases the quantity, and if he finds it is too great, by partially closing the cock decreases it. After the juice is limed it passes to Deming horizontal superheaters, kept at 220° F., and is run from these into absorbers, where the gases and air included in the juice escape through a pipe inserted in the top of the vessel. These hot gases are used for heating the juice that comes from the filter presses.

From the eliminators the juice passes to six Deming separators. These are cylindrical vessels, cone-shaped at the basal end; four of them have a capacity of 12,000 gallons, and two of 10,000 gallons each. The settlings from these separators are drawn off every twenty minutes, and run into tanks, where, by means of cocks at various heights along the sides of the tanks, the clear juice is withdrawn. The residue is run into separate tanks, and after 50 per cent of water is added, is thoroughly mixed, steamed, and passed through a range of thirty-four filter presses. The clear juice from the Deming separators is sent to the Lillie quadruple evaporators, of which there are three, capable of evaporating 40,000 gallons of mixed juice each, to sirup of 28° to 30° Baumé, in twenty-four hours. In addition to the Lillie evaporators, there has been recently installed a Kestner climbing film evaporator.

From the evaporators, the juice is pumped into tanks, whence it is drawn by the vacuum pans, of which there are six, two 12½ feet in diameter, and four 12 feet in diameter. Each part contains, when fully charged with massecuite, sufficient to yield about 27 tons of dried sugar per strike. The massecuite from the pans is discharged into the crystallizers, and allowed to remain for five hours; it is then run into pug mills, and on to the electrically driven centrifugals, of which there are thirty-three. These run at the rate of 1,000 revolutions per minute. The molasses from the first sugar is reboiled; this is done by first graining the pan with sirup, and then the molasses, which has been diluted

with hot water to 30° Baumé, is taken into the pan as required. If possible, this is boiled eight hours, and then discharged into crystallizers, where it remains for about six days.

The crystallizers are circular vessels 19¼ feet long by 9 feet in diameter; inside of them there are revolving fans, and they are jacketed for steam or cold water. It is estimated that 10 feet of crystallizer space is sufficient per ton of cane crushed per day. As the sugar leaves the crystallizers it is mixed, by means of an Archimedean screw conveyor, with the first sugars, and taken by a bucket elevator to a receiver, whence it is run into bags resting on small platform scales, weighed, sewn up, and taken to an elevator which conveys it to the sugar store, whence it is shipped direct to vessels, by means of a tram line of about 300 yards.

The mixed sugars have an average polarization of 96°, the first sugar being 97° and the sugar molasses 94°. The molasses from the second sugars, of which there remains about 65 gallons per ton of sugar, is pumped into large tanks, and taken by tank steamers to the United States for the purpose of making whisky. The purity of the residual molasses is about 28 per cent.

With regard to the land supplying canes to the factory, at present there are something like 11,000 acres of canes grown by the South Porto Rico Sugar Company on its own account, in addition to the canes obtained from a large number of colonos. On most estates there is an admirable system of irrigation. At some of the pumping stations, petrol engines are used for the motive power; at others, particularly those in the neighborhood of the factory, the pumps are operated by electricity. This is generated at the sugar factory and conveyed by cables to the various stations. Where there is not sufficient rainfall, an effort is made to supply each acre of canes with 50,000 gallons of water every ten days.

The land is almost in every instance either prepared by steam, or bullock-drawn plows. Where the steam plows are to be used, as soon as the canes are cut, the fallen leaves are burned and the land is immediately plowed, harrowed, and then, by means of double mold-board plows, furrowed. The canes are planted in the bottoms of the furrows about 2 feet 6 inches apart, the cuttings being similar to those used in Barbados; the water, where they are irrigated, is then run along the furrows. As soon as the young canes are about 18 inches to 2 feet high, chemical fertilizers are strewn on each side of the clumps, and a small plow drawn by a mule is used to throw some of the soil from the banks on to the stools. Until the canes are too advanced to prevent their use, cultivators are worked on the banks, in order to keep the fields, as far as possible, free from weeds.

SUGAR MACHINERY IN PORTO RICO.[1]

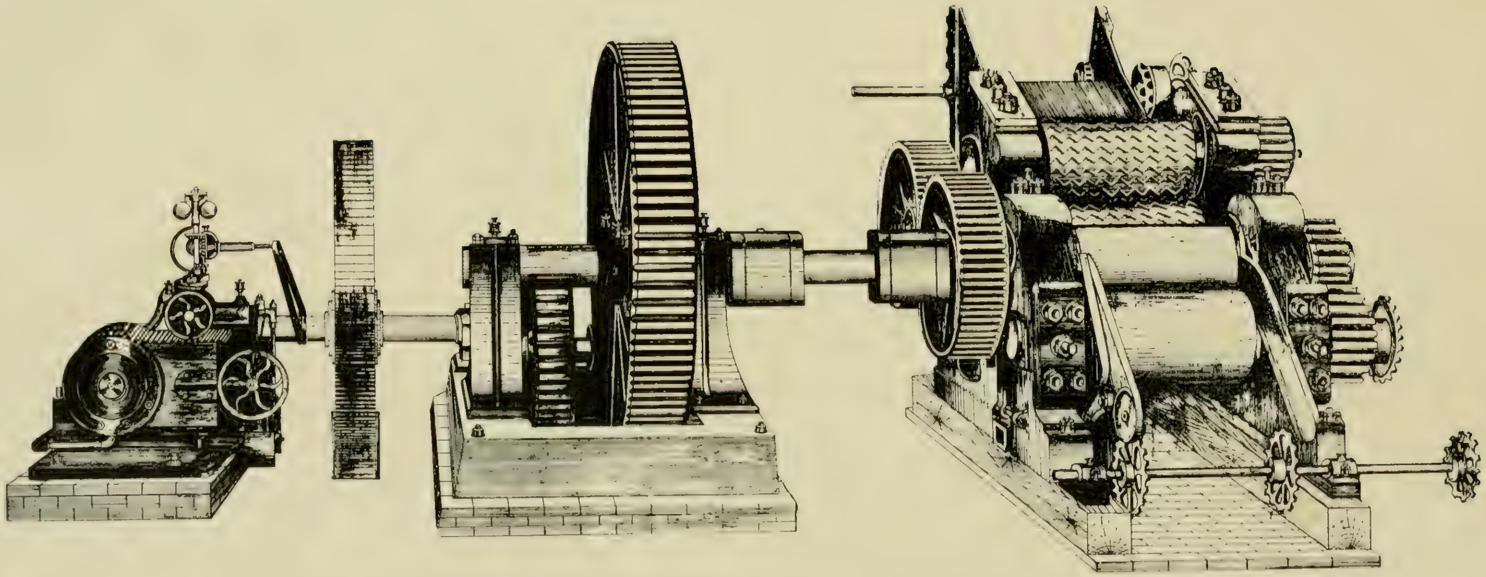
In a letter to The Times, a correspondent in Porto Rico refers at some length to the sugar-machinery trade in that island. He points out that since the present tariff—free trade for the States and prohibitive duties for all outsiders—was enforced there by the United States the importations of sugar machinery from Great Britain have been very small and dependant on special conditions. The Germans, however, still have a good deal of trade with Porto Rico in spite of the high duties; they are the only nation that still compete to any extent with the United States there. The latest American crushing machinery in the island consists of 17-roll sets; i. e., five 3-roll mills and a 2-roll crusher, the whole driven by two engines. An improvement on this is already foreshadowed in an 18-roll set; i. e., six 3-roller mills with each of the first two mills having Diamond top rollers. These Diamond rolls have given excellent results, and are, all things considered, much better than a two-roll crusher.

A further improvement, says this correspondent, would be to drive these eighteen rolls by one steam turbine instead of two reciprocating engines. The turbine arrangement offers no difficulty, and the saving in cost, foundations, steam, oil, and attendance would be considerable. The exhaust steam in a sugar factory is used for evaporating and granulating the cane juice, and the condensations are returned to the boilers. The presence of oil in the exhaust steam from reciprocating motors is therefore very injurious. With turbines this trouble is entirely eliminated. So far as present experience goes, the most perfect sugar factory should have steam motors (turbines) for the milling and electric plants, and all other motors in or connected with the factory should be electric. A single milling set as above indicated can be constructed to work almost automatically, to handle over 2,000 tons of cane per twenty-four hours' work, and, with canes averaging 11½ per cent fiber, to give an average extraction of 85 pounds of juice per 100 pounds of cane, with less attendance than usually required with plants working 300 to 400 tons of cane in the twenty-four hours, with an extraction of about 75 per cent.

The largest company expects to turn out this year close on 100,000 short tons of 96° polarization sugars from three factories all connected by railway. The

[1] From the International Sugar Journal, vol. 13, No. 149, May, 1911.

largest of these three factories has four sets of 14-roll mills, with a capacity of 5,000 tons daily. That factory has a steam electric plant of over 2,000 horsepower to supply current for the motors in the factory and the electrically driven irrigation pumps for many miles around. The company's latest installation has only one crushing plant, consisting of five 3-roll mills and one 2-roll crusher, with a capacity of 1,500 tons of cane daily. The average extraction is 85 pounds of juice per 100 pounds of cane. This factory has one steam electric unit of 800 horsepower and three producer gas units of 300 horsepower each. With the exception of the mill engines nearly all the motors are electric. The current leaves the dynamos at about 320 volts, and after being transformed up to 15,000 volts is sent many miles over the fields to the irrigation pumping stations.



AN IMPROVED THREE-ROLLER MILL WITH ZIGZAG CRUSHER, GEAR-BED, AND ENGINE. (Squier.)

PLATE XXII.

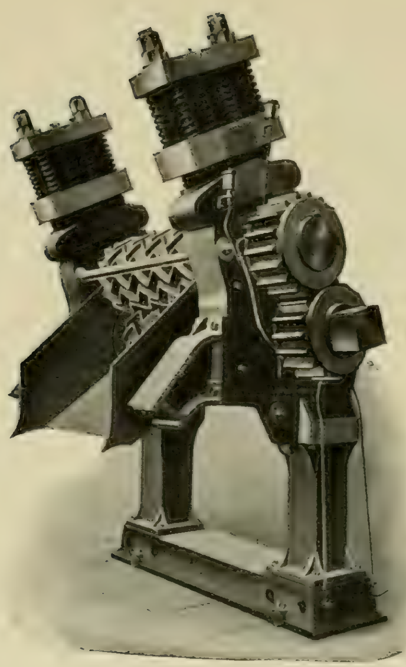


Fig. 1.—THE ZIGZAG CRUSHER AS MADE FOR ATTACHMENT TO EXISTING MILLS. (Aitkin.)

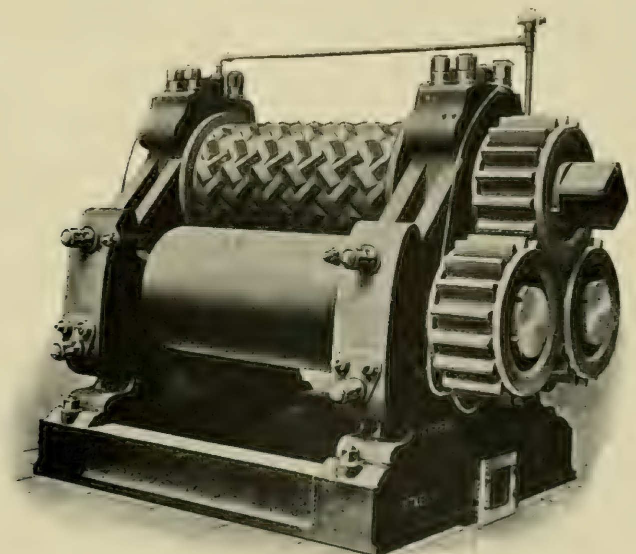


Fig. 2.—A THREE-ROLLER MILL CHANGED TO A CRUSHER BY ADDING A DIAMOND-TOP ROLLER. (Aitkin.)

PLATE XXIII.

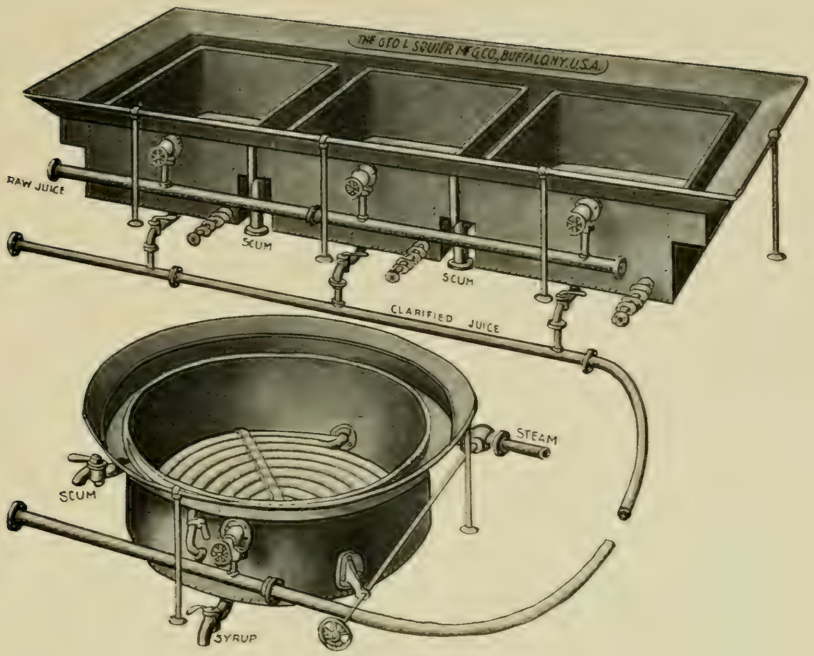


Fig. 1.—STEAM CLARIFIER AND OPEN STEAM EVAPORATOR. (Squier.)

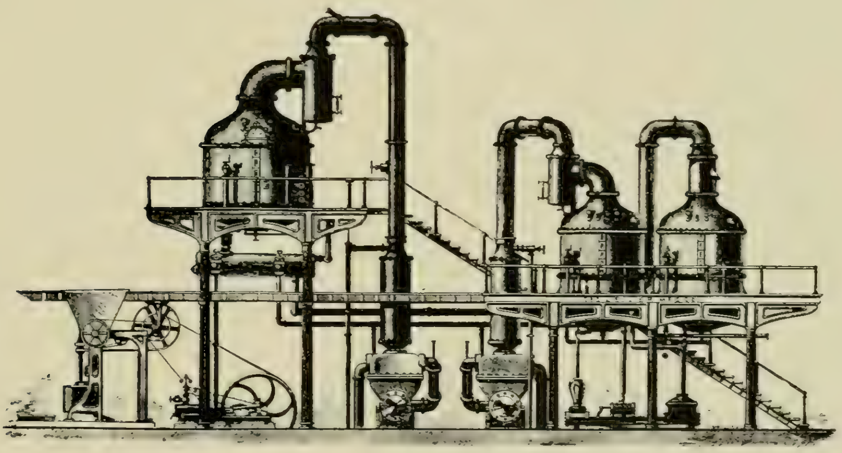
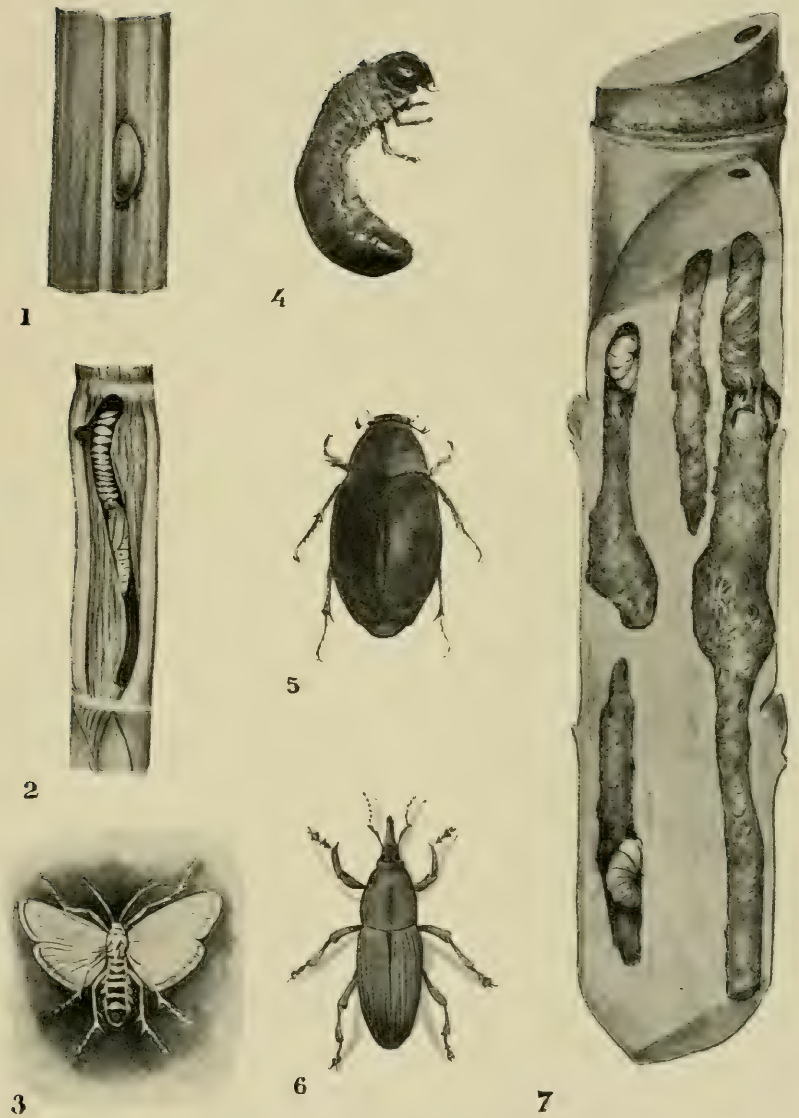


Fig. 2.—SMALL DOUBLE-EFFECT VACUUM PAN AND CENTRIFUGALS. (Squier.)

PLATE XXIV.



INSECT ENEMIES OF SUGAR CANE.

(1) Egg mass of Tip Borer (*Scripophaga intacta*) ; (2) Gallery and pupa (*Scripophaga intacta*) ; (3) Adult (*Scripophaga intacta*) ; (4) Larva of Cane-root Beetle (*Holotrichia vidua*) ; (5) Adult of Cane-root Beetle (*Holotrichia vidua*) ; (6) Red Cane Weevil (*Sphenophorus* sp.) ; (7) Cane showing galleries of weevil and grubs.

PLATE XXV.

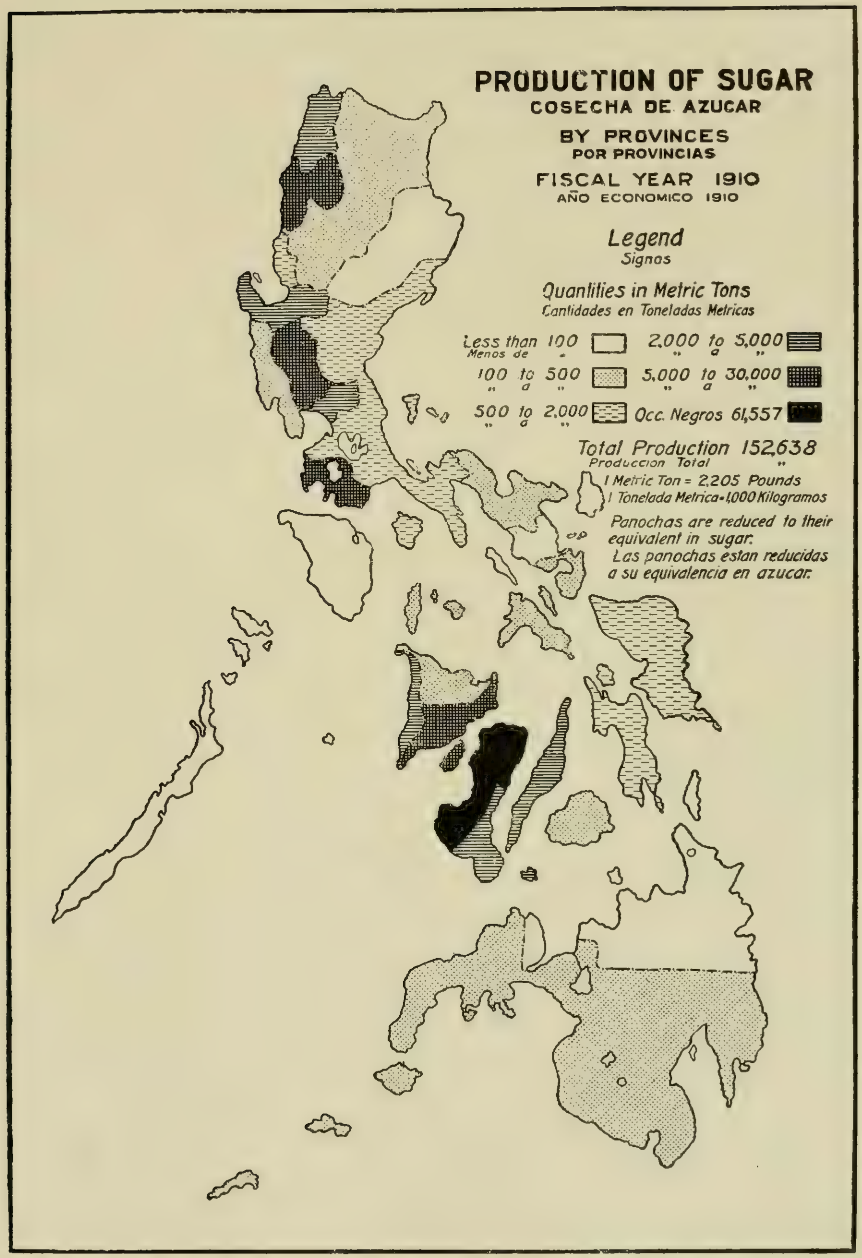

PRODUCTION OF SUGAR
COSECHA DE AZUCAR
BY PROVINCES
POR PROVINCIAS
FISCAL YEAR 1910
AÑO ECONOMICO 1910
Legend
Signos
Quantities in Metric Tons
Cantidades en Toneladas Metricas
Less than 100
Menos de
100 to 500
500 to 2,000
2,000 to 5,000
5,000 to 30,000
Occ. Negros 61,557
Total Production 152,638
Produccion Total
1 Metric Ton = 2,205 Pounds
1 Tonelada Metrica = 1,000 Kilogramos
Panochas are reduced to their equivalent in sugar.
Las panochas estan reducidas a su equivalencia en azucar.

PLATE XXVI.

IMPROVEMENT OF EXISTING MILLS.

The evolution of sugar mills.—The history of the sugar industry tends to show that it has gone through a gradual evolution to its present status. With the possible exception of Formosa, there has been no radical change directly from the small plantation mill to the large modern factory. Even in those countries like Cuba and Porto Rico there are still a great many small mills that are entirely out of date as compared with the most modern factories of those countries. In the Hawaiian Islands the excellent system and equipment for the manufacture of sugar has been developed from the small wooden mill made by the missionary, through the Chinese mills with their two stone rollers, the small three-roller mills propelled by animal power, the three-roller plantation mills like those of the Philippines, all of which have finally been displaced by modern mills of all descriptions up to eighteen-roller combinations.

The manufacturing equipment in the Philippines was as good as that in any similar country at the time it was installed, but circumstances which have been briefly explained, stopped the development in this direction more than fifteen years ago. Since then the manufacturing equipment here has been entirely outclassed by the more modern mills like those of Java, Hawaii and Formosa.

Present tendencies.—There are a great many owners of plantations here with one or more mills who are willing to enter into an arrangement by which their land will become a part of the territory that will supply cane to a central mill, and thereby dispense with the necessity for operating small mills now on such land. There are others who prefer to improve their mills and continue in complete control of the property and its operation. There are also a large number of Philippine sugar planters who are content with their present methods and equipment so long as profits can be made by their use without change. However, the time is not far distant when all of the sugar growers here will realize that the greatest opportunity for profit will be brought about only when radical improvements are made in the present milling plants, or they are abandoned entirely in favor of the modern central.

Proposed improvements.—The writer desires to offer a few suggestions with reference to the improvement of existing mills so as to fit them for turning out a standard grade of sugar, which would result in greatly increased profits. The smaller mill owners could then combine these profits to provide the capital for the establishment of improved central mills.

The existing small plantation mills consist essentially of three parts. The first is the crushing plant which includes the three-roller mill with stationary feed table. The accompanying illustration of the water-driven mill at La Granja Modelo, with rollers 45.72 by 91.44 centimeters (18 by 36 inches) may be taken as a typical mill of the period in which it was installed (1886). There are a few mills in the Islands having larger rollers, and most of them are driven by steam engines, but the great majority are of a smaller size and correspondingly less efficient.

These mills would be much more efficient both in capacity and the quality of work done if provided with a crusher. This course we recommend for mills large and strong enough to do a good class of work, but is not to be recommended for mills having rollers less than 50 centimeters in diameter by 1 meter long. A still better form of mill on which to make such improvements would be those having larger and shorter rollers, such as 60 centimeters in diameter and 1.12 meters long. The difference in the extraction of juice from cane is shown by the following estimates furnished by Fred Wilson & Co., sugar engineers, Manila:

Style of equipment.	Per cent juice on weight of cane.	Per cent of pure sugar.
3-roller mill without crusher	55	8.51
3-roller mill with crusher	70	10.83
6-roller mill with crusher	81	12.54
9-roller mill with crusher	83.6	12.939

The accompanying illustration (Plate XXXII) shows a three-roller mill with crusher, intermediate gear and engine as placed on the market by American manufacturers. It is an excellent type of mill for small plantations, and is recommended where new mills are to be purchased.

The plantation sugar mill engines in general use are of the small, high-pressure, low-speed type with heavy flywheel and direct connected through the intermediate gear to the mill. They are for the most part of Scotch manufacture, are well built and quite serviceable for driving the mills for which they were purchased. They would not furnish power to operate additional sets of rollers or crushers and such equipment must have separate power or a larger engine capable of driving the combination must be purchased. The latter plan is to be recommended if ready sale can be found for the small engine, or when it can be utilized for other work about the mill, such as driving the cane carrier, centrifugals, pumps and other minor machinery. The small engines on the larger plantations will be ample for driving the smaller mills without crusher combinations. The larger engines may continue in use for driving the mills with which they were purchased, in which event a separate engine could be provided for driving the crusher.

The boilers in use with these mills are generally of a good type but of a capacity suitable for generating only sufficient steam for the mill engine. Any additional requirements would necessitate providing additional boiler capacity. A good boiler need not be discarded but can be satisfactorily used in the power plant in connection with other boilers, preferably of the same type, size and pressure.

The increase should be sufficient so that the entire boiler capacity will provide the necessary power to drive all of the machinery operated in the mill and supply sufficient exhaust and live steam for doing all of the evaporating. This would necessitate the reconstruction of the boiler settings so as to provide green bagasse furnace for burning vegetable matter carrying from 45 to 55 per cent of moisture, and the installation of the necessary bagasse carriers for feeding the refuse from the mill directly into the Dutch oven furnace which should be fitted with step-ladder grate, the same as the large central mills. This arrangement would dispense with all labor now required for handling the cane into the mill, the movement of bagasse to the yard, handling while it is being dried, and returning it to the furnace-room, and make the operation of the mill possible even during the heaviest rains when the drying of bagasse is impossible.

The only type of evaporating plant in use consists of a series of cast-iron caldrons, or *cauas,* set in a furnace, the simplest form of which is illustrated in the accompanying cut made from a drawing. There are a few pieces of auxiliary machinery and equipment to be found in sugar mills of the Islands. Occasionally a juice pump is attached to a crank arranged on one of the mill rollers or engine, but the writer has never seen a separately operated steam geared or belted pump in a Philippine sugar mill. Settling tanks are generally used in the larger mills but without any definite plan for their operation. There is often found some form of filter press, the simplest type of which is the one consisting essentially of a wooden box with a weighted follow-block. The bags of scum or settlings are placed inside of the box and pressure applied by direct weighing. Occasionally a small standard filter press is to be seen and sometimes they are so operated as to do good work. Clarification is accomplished principally by skimming the juice during the process of evaporation. There are a very few steam-heated clarifiers and one open steam evaporating pan in use in Negros. Several mills have from time to time purchased centrifugals under the impression that this class of machinery could be operated on concrete sugar as made in the Philippines. These purchases were generally made on the recommendation of machinery dealers rather than from a knowledge of their use and operation in the sugar industry. Of course, they have been a general failure and in some cases the purchasers have become thoroughly convinced that centrifugal machines are of no value in the Philippines.

Cane carriers are highly desirable, even where mills have a capacity

of only 150 tons of cane a day, especially where rail transportation is used.

A regular and adequate system for handling and clarifying all of the juice extracted by the mill should be operated. This should consist of liming tank and an ample supply of settling tanks so that the juice may remain in them long enough for all of the sediment to settle to the bottom and permit the scums to rise to the surface. A modern filter press should be installed for handling all of the sediment and scum from the settling tanks. The entire open kettle evaporating outfit should be replaced by the installation of steam evaporating apparatus either of the open kettle or vacuum type. If actual capital is limited, a combination may be made by installing open kettle clarifiers and syrup pans with a vacuum pan for finishing the sugar. However, for a small plantation mill great economy would result by the installation of a small double effect, vacuum pan and centrifugal equipment, as shown in the accompanying illustration (Plate XXXIV). These double effects are almost as economical as the triple and quadruple effects described for the large modern mills, and are within the reach of a comparatively small plantation. The installation of effects less than 1.5 meters in diameter or of vacuum pans having a capacity of less than 5 tons at a single charge, is not recommended. A mixer should be provided to accompany the centrifugals for receiving the sugar from the vacuum pans or cooler cars but no elaborate crystallizer outfit is recommended for such reconstructed mills.

A battery of from three to four 30-inch, belt-driven centrifugals with suspended baskets will be ample for the size of mills under consideration.

A sugar melting pan can be devised on the plantation out of galvanized iron or wood, and many other articles for convenience can be constructed on the plantation with but little cost. Sugar should be packed in a good quality of burlap bag, and where "plantation granulated" sugar is turned out for local consumption it should be packed in double bags, the inner of which should be made of white cotton cloth. This grade of sugar usually requires some drying which can be accomplished by the use of a rotary drier. An inexpensive form of drier made of a wooden box, carrying a steam coil and fitted with a fan for blowing the sugar through the heated air of the box is a much more desirable form for use in the small mills.

The general use of scales is recommended for weighing all cane as received at the mill, the juice as it goes to the liming tank and the sugar as delivered from the centrifugals.

The installation of light portable tramways with 1 to 2 ton cars arranged for animal power is highly recommended for all plantations producing 5,000 tons of cane or more.

STATISTICS ON SUGAR IN THE PHILIPPINE ISLANDS.

Cultivated area and available sugar land.—In 1908 Mr. John S. Hord, then Collector of Internal Revenue, made a thorough canvas of the sugar industry of the Islands through the local internal-revenue agents. They visited most of the farms of any consequence and secured a sworn statement from practically every cane grower as to the area he had in cultivation and the amount of his land deemed suitable for sugar growing. The results of this investigation are shown in the following table:[1]

Province.	Area of growers' land actually cultivated in sugar.	Area of growers' land adapted to sugar culture, but not so planted.
	Hectares.	*Hectares.*
Agusan		
Albay	17.73	36.34
Ambos Camarines	166.91	85.78
Antique	1,041.58	850.00
Bataan	161.19	373.36
Batangas	3,651.66	11,957.96
Benguet		
Bohol	182.93	457.96
Bulacan	2,784.61	916.55
Cagayan		
Capiz	341.54	1,158.17
Cavite	1,025.32	2,146.50
Cebu	1,956.52	5,362.55
Ilocos Norte	195.00	
Ilocos Sur	1,551.62	2,151.70
Iloilo	2,508.56	7,745.65
Isabela		
La Laguna	1,014.82	8,195.52
La Union	426.35	154.05
Lepanto-Bontoc		
Leyte	408.19	1,082.32
Masbate		
Mindoro		
Misamis	60.49	
Moro	1,091.22	40.73
Nueva Ecija	630.46	106.44
Nueva Vizcaya		
Occidental Negros	24,748.00	37,044.00
Oriental Negros	2,348.00	1,501.00

[1] Philippine Agricultural Review, Vol. III, No. 5, May, 1910.

Province.	Area of growers' land actually cultivated in sugar.	Area of growers' land adapted to sugar culture, but not so planted.
	Hectares.	*Hectares.*
Palawan		
Pampanga	13,500.81	14,006.28
Pangasinan	1,299.70	682.11
Rizal	413.66	206.84
Samar	85.68	14.84
Sorsogon	14.19	
Surigao	20.24	18.83
Tarlac	6,382.63	4,929.86
Tayabas	62.24	2.89
Zambales	39.02	104.05
Manila		
Total	68,130.87	101,332.28

The crop of 1909–10.—The total area in cultivation, the yield of the sugar crop of the Philippines and its distribution for the fiscal year ending June 30, 1910 are shown by the following table compiled from statistics collected by the Bureau of Agriculture:[1]

Province.	Amount of sugar produced.		Area cultivated.	Production per hectare.
	Piculs.	*Metric tons.*	*Hectares.*	*Kilos.*
Agusan				
Albay	1,146	72	141	514
Ambos Camarines	3,081	195	367	531
Antique	53,186	3,364	1,580	2,129
Bataan	7,491	474	341	1,389
Batangas	190,955	12,078	5,183	2,330
Bohol	1,941	123	166	739
Bulacan	54,442	3,443	2,935	1,173
Cagayan	2,154	136	281	484
Capiz	6,729	426	385	1,105
Cavite	24,910	1,576	1,198	1,315
Cebu	33,007	2,088	1,866	1,118
Ilocos Norte	41,443	2,621	2,338	1,121
Ilocos Sur	101,116	6,396	3,412	1,874
Iloilo	124,564	7,879	3,408	2,311
Isabela	475	30	42	715
La Laguna	23,880	1,510	741	2,038
La Union	24,934	1,577	1,018	1,549
Leyte	10,854	687	815	843
Mindoro	177	11	19	589
Misamis	726	46	34	1,350
Moro	1,620	102	119	861
Mountain	2,274	144	175	821
Nueva Ecija	10,055	636	527	1,206
Nueva Vizcaya	617	39	60	560

[1] From the Philippine Agricultural Review, Vol. IV, No. 6, June, 1911.

Province.	Amount of sugar produced.		Area cultivated.	Production per hectare.
	Piculs.	*Metric tons.*	*Hectares.*	*Kilos.*
Occidental Negros	973,231	61,557	26,820	2,295
Oriental Negros	48,266	3,053	1,410	2,165
Palawan	60	4	5	759
Pampanga	454,264	28,732	16,551	1,735
Pangasinan	35,338	2,235	2,794	800
Rizal	30,345	1,919	1,752	1,095
Samar	8,622	545	667	818
Sorsogon	7,292	461	398	1,159
Surigao	425	27	47	572
Tarlac	115,810	7,325	4,427	1,654
Tayabas	15,148	958	1,005	953
Zambales	2,692	170	141	1,207
Total	2,413,270	152,639	83,168	[1] 1,835

[1] Average.

NOTE.—1 picul=63.25 kilos. 1,000 kilos=1 metric ton.

The total crop as shown by this table is believed to be slightly below the actual production, as it has been found difficult to secure complete reports from all of the provinces. However, the amount unreported is quite small and is all consumed locally.

The differences between the provinces in production per hectare, aside from those arising from varying soil fertility, are in part accounted for by destruction in some localities from drought or storms, or because of locusts or rats. Locusts in some places destroyed a great deal of cane at an early stage of growth, some municipalities reporting an almost total loss.

Mr. W. B. Gonder, sugar chemist of the Bureau of Science, states that the average polarization of sugar sold on the Iloilo market during the first half of the year 1911 was 82.6 degrees. If this is true for all of the sugar produced in the Islands, the 152,639 ton crop of 1910 was equal to only 131,332.28 tons of 96 degree centrifugal sugar.

Disposal.—The disposal of this sugar was as follows:

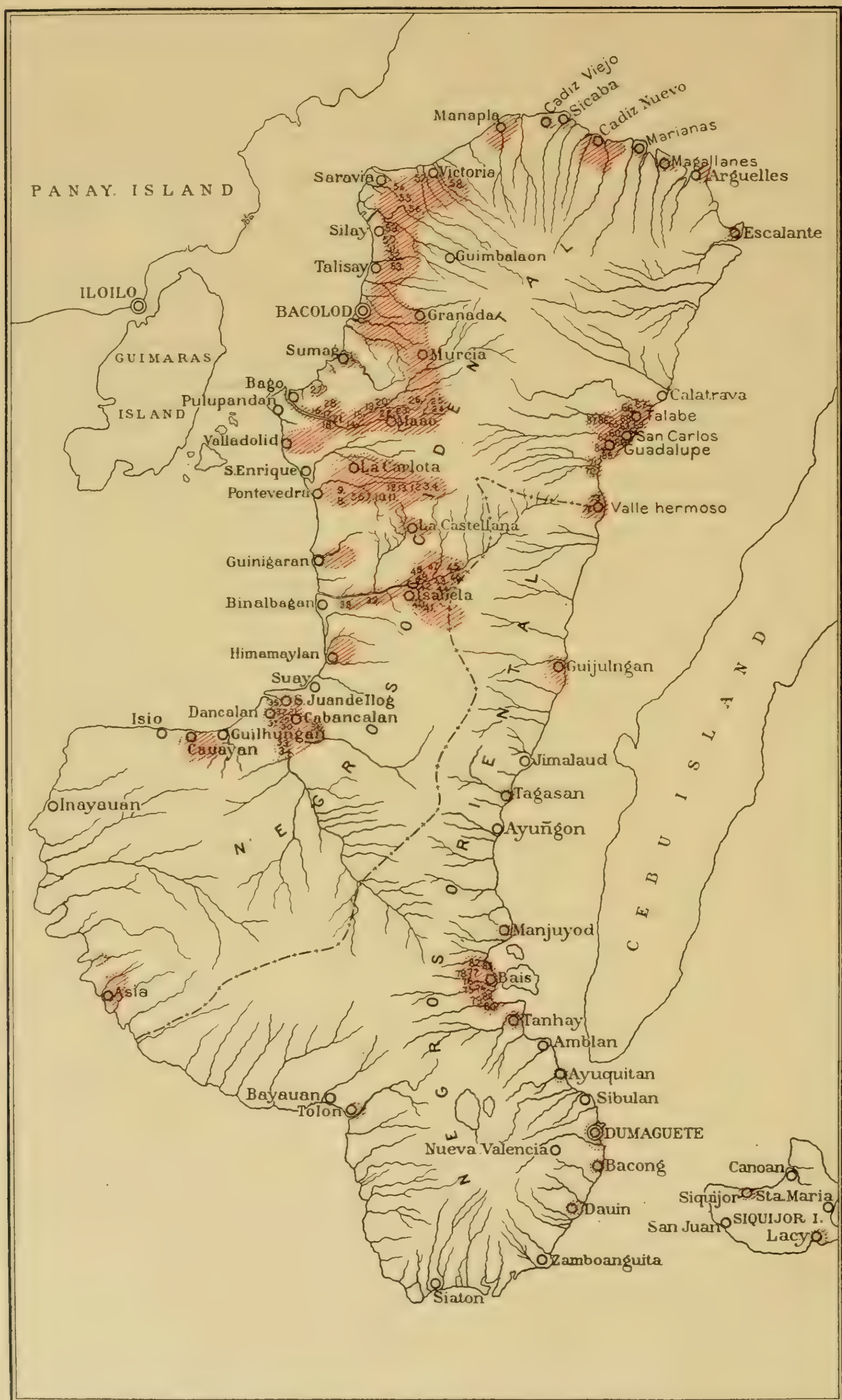
	Metric tons.
Exported to the United States	92,668
Exported to other countries	33,000
Consumed in the Philippines	27,971

To the local consumption here shown must be added the unreported sugar referred to above.

Exports of sugar, 1910–11.—The total exports of sugar from the Philippine Islands for the year ending June 30, 1911, were 149,376 metric tons, valued at ₱16,028,720. The exports to the United States for this period were 128,926 tons, and to all other countries 20,450 tons.

Part II

THE SUGAR INDUSTRY IN THE ISLAND OF NEGROS



MAP OF THE ISLAND OF NEGROS, SHOWING THE PRESENT SUGAR DISTRICT.

DEPARTMENT OF THE INTERIOR
BUREAU OF SCIENCE

THE SUGAR INDUSTRY IN THE ISLAND OF NEGROS

BY

HERBERT S. WALKER

(From the Division of Chemistry, Government Sugar Laboratory at Iloilo, Philippine Islands.)

MANILA
BUREAU OF PRINTING
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2. Loading sugar on lorchas in the Bago River for transportation to Iloilo.

Plate X.

Fig. 1. The Bago River and the sugar lorchas of the Hacienda Lumañgub. This is the farthest point up the river to which lorchas can go.

2. Temporary experimental laboratory.

PREFACE.

Several years ago the Director of the Bureau of Science realized the necessity of making an extended and thorough study of the sugar cane produced in the Philippine Islands, the nature of the soils as disclosed by chemical and physical examination, the area planted and the area available for sugar production. It was deemed necessary at the same time to tsudy the existing methods of isolating the sugar and shipping it to the market in order to determine the benefits which might accrue from improved methods of grinding and evaporating. The necessity for this work was emphasized in the Annual Report of the Bureau of Science for the year 1908, and it was proposed to establish a staff which would employ at least three men for a sufficient length of time to complete the investigations; the undertaking including assistance from other Bureaus in the preparation of topographic maps. However, the Government did not believe itself in a position to inaugurate so extensive a piece of work at that time. Therefore, it was decided to do as much as possible with the laboratory force available to us, and in view of the fact that the Island of Negros produces the greatest amount of sugar for any given area in the Philippine Islands, it was deemed expedient to concentrate our efforts on that region. Mr. Herbert S. Walker, of the chemical laboratory, was detailed for this duty, he being stationed in Negros during the entire sugar campaign of 1908 and 1909 and, in addition, giving to the subject the attention necessary to complete the work as far as it was possible for one man so to do. He carried with him a portable chemical laboratory and hand mill and established his laboratory on the various haciendas in the island. The information which he was able to obtain was therefore gained at first hand. The soil analyses and such other chemical work as could not be performed on the spot were done at the central laboratory in Manila by Messrs. L. A. Salinger, R. R. Williams, and Wallace E. Pratt, the first two being of the division of chemistry and the latter of the division of mines of the Bureau of Science. The work which is published in the following monograph speaks for itself. Much remains to be done, even after considering the thorough and exhaustive report which has been made, especially in the direction of a study of fertilizers on the spot and in the introduction of other varieties of cane which would be available in case of accident to the present types

so extensively grown. However, in order to accomplish such a result the chemical laboratory must give way to the experimental station. The sugar production in other parts of the Philippine Islands will be taken up as opportunity permits.

The Bureau of Science wishes to express its thanks to all of the hacenderos of Negros who so courteously helped in this work, not only by supplying quarters for the laboratory, but by means of other assistance which often involved a considerable sacrifice of time on their part.

PAUL C. FREER.

THE SUGAR INDUSTRY IN THE ISLAND OF NEGROS.

By HERBERT S. WALKER.

(From the chemical laboratory, Bureau of Science, Iloilo sugar laboratory.)

INTRODUCTION.

The Philippine Islands in general and the Island of Negros in particular, with reference to the condition of their sugar industry, have probably been as thoroughly discussed and investigated as any sugar-producing country in the world, and with as little true knowledge of the facts. At least two large volumes bearing directly on this subject have already been published,[1] containing most highly variegated and conflicting testimony from more or less prejudiced parties. While undoubtedly many true and conservative statements are contained therein, they are so covered up by a mass of exaggerated conjectures and estimates made by over-eager friends and enemies of the Philippines as to be practically valueless as a source of information. During the past year, however, the Bureau of Internal Revenue has made a very thorough study of the sugar industry in these Islands from a statistical point of view, and secured reliable data as to the total area of lands planted and available for sugar culture and the amount of sugar actually produced in each municipality throughout the Islands, together with statements from individual planters in regard to the cost of production.

The object of the present investigation was to learn at first hand the conditions of agricultural practice in cane growing and sugar making actually prevailing here at the present time, and thus to prepare a foundation on which to base future efforts toward the advancement of the industry. It is obvious that only with an exact knowledge of facts concerning our own resources and conditions can we hope, by comparing them with those of other countries, to suggest means or to work out methods for their improvement. With this end

[1] Hearings before the Committee on Ways and Means, 1905. Hearings before the Committee on the Philippines of the United States Senate, 1906.

in view, the writer spent six months, or practically the entire milling season of 1908–9, on the Island of Negros, taking with him a portable laboratory for the analysis of canes, mill juices, bagasse, and sugar-house products, and, through the courtesy of the planters, was facilitated with conveniencies for carrying on his work directly on the plantations in the more important sugar districts of the island, being at the same time afforded an opportunity of observing the methods commonly employed in the cultivation of cane and the production of sugar. Representative samples of soil were also secured from each locality, together with all possible data as to their productiveness in quantity and quality of cane and sugar yielded.

It was manifestly impossible in such an investigation to cover the whole Philippine Islands during one season. Choice must be restricted to a few typical localities in the largest sugar-producing section of the Islands. In point of total sugar produced, Negros has for many years led all other provinces; during the past forty years it has been more closely and intensely devoted to this branch of agriculture than any other section of the country; and, owing to the practical dependence of the majority of the inhabitants on the yearly sugar crop for a livelihood, the industry has been more highly developed here than in the majority of other sections. Out of a total of approximately 180,000 metric tons of sugar made in the Philippine Islands during the season of 1907–8, 73,498, or a little over 40 per cent, came from the Island of Negros alone. In 1893, the year of largest production for the Islands, Negros gave about 115,000 metric tons out of a total of 300,000. Here also may be found soils of every degree of fertility, from virgin forest lands and rich alluvial deposits to worn-out fields which have been cultivated for upwards of fifty years without fertilizing.

GENERAL INFORMATION REGARDING NEGROS.

GEOGRAPHICAL LOCATION.

Negros is situated at from 9° 4′ to 11° 1′ north latitude and from 122° 24′ to 123° 34′ east longitude. Three other important islands practically surround it: Panay on the north and west, at a distance of from 13 to 70 kilometers; Mindanao on the south, some 45 kilometers at the nearest point; and Cebu, distant 4 to 25 kilometers from the coast. Manila is some 500 kilometers northwest of Negros, while Iloilo, the principal shipping point for sugar, is distant about 45 kilometers from the west and 100 to 150 kilometers from the east coast.

SIZE, SHAPE, AND AREA.

Negros measures 200 kilometers in its greatest extension from north to south. In outline it is shaped roughly like a boot, the greatest

breadth in the lower part being in the neighborhood of 90 kilometers, and the upper half, containing most of the sugar lands, varying from 40 to 60 kilometers. The total area of the island is probably not exactly known; it has been stated by different authorities to be from 9,000 to 12,500 square kilometers.

MOUNTAINS.

By far the greater part of this area is occupied by mountainous or hilly forest lands, which are uncultivated, except for occasional small patches, "caingins," burned and planted for a season or so in corn by the semiwild mountain people. These mountains extend for the entire length of the island from north to south, but are much nearer to the east than to the west coast. The land itself is of volcanic origin, and the highest peak, Mount Canloan, is still partially active to the extent of sending forth occasional puffs of smoke.

RIVERS.

But one river, the Danao, is navigable for vessels of any considerable draft, and this lies in the mountainous, extreme northeastern part of the island, which is of little importance for sugar production. Three others—the Bago, the Binalbagan, and the Ilog—penetrate important sugar districts and permit entrance by flat-bottomed sugar "lorchas" for distances of from 5 to 10 kilometers. Countless other small streams break up the entire coast line of the island, but they are of very little importance except where they occasionally serve as sheltered landing places for small boats. It is owing to this lack of large rivers and harbors suitable for seagoing craft that no sugar is exported directly from Negros, but all is taken across in small sailing boats to Iloilo, the nearest large port. In fact the town of Iloilo owes its existence largely to the sugar industry of Negros.

CLIMATE.

The following data compiled by the Weather Bureau show the monthly maximum, minimum, and average temperature and rainfall at two meteorologic stations in Occidental Negros, one during the period 1891–1898 at La Carlota (La Granja Modelo), the other during 1903–1908 at Bacolod. In a country so broken by mountains as is Negros, the rainfall is especially liable to local variation, and it is no uncommon occurrence for one plantation to be without rain for several weeks, while a neighboring one may be enjoying daily showers. This is especially true in the northern and eastern parts of the island. No meteorologic station has been established as yet in Oriental Negros.

Maximum, minimum, and monthly mean of rainfall at La Carlota, Occidental Negros, deduced from the period 1889–1897.

Month.	Monthly maximum.		Monthly minimum.	
	Millimeters.	Year.	Millimeters.	Year.
January	179.9	1891	6.1	1896
February	144.5	1893	0.0	1897
March	113.0	1897	8.4	1889
April	292.9	1890	3.0	1889
May	477.0	1893	44.4	1889
June	415.0	1895	175.9	1891
July	607.0	1896	114.9	1894
August	588.0	1891	232.0	1894
September	623.4	1894	234.0	1896
October	887.8	1892	106.6	1895
November	368.4	1889	47.5	1896
December	262.9	1889	9.0	1896

Average of rainfall at La Carlota, Occidental Negros, deduced from the period 1889–1897.

	Millimeters.		Millimeters.
January	59.7	July	358.7
February	55.6	August	378.6
March	47.4	September	392.9
April	87.0	October	350.9
May	229.3	November	199.0
June	304.8	December	127.3

Maximum and minimum of temperature for each month of the year at La Carlota, Occidental Negros, deduced from the period 1891–1898.

Month.	Monthly maximum.		Monthly minimum.	
	°C.	Year.	°C.	Year.
January	34.0	1893	17.4	1893
February	34.9	1892	18.0	1893
March	35.5	1892	18.9	1893
April	36.4	1891	19.5	1892, 1894
May	35.6	1891	20.8	1894
June	34.1	1892	19.2	1895
July	34.8	1892	19.0	1895
August	33.4	1892	19.5	1895
September	33.5	1891	19.0	1893
October	34.9	1892	20.3	1891
November	33.6	1892	19.8	1895
December	34.7	1892	17.0	1892

Average of temperature for each month of the year at La Carlota, Occidental Negros, deduced from the period 1891–1898.

Month	°C.	Month	°C.
January	25.6	July	26.3
February	26.3	August	26.0
March	26.7	September	26.2
April	27.6	October	26.7
May	27.6	November	26.3
June	27.0	December	26.0

Maximum and minimum of rainfall for each month of the year at Bacolod, Occidental Negros, deduced from the period 1903–1908.

Month.	Monthly maximum.		Monthly minimum.	
	Millimeters.	Year.	Millimeters.	Year.
January	255.7	1907	51.3	1903
February	178.3	1904	0.3	1906
March	36.9	1903	1.6	1905
April	113.4	1904	1.1	1905
May	206.2	1908	91.3	1903
June	399.2	1904	145.9	1905
July	415.1	1906	233.3	1907
August	433.8	1907	200.2	1903
September	417.1	1908	227.6	1905
October	362.5	1905	100.5	1908
November	189.8	1908	96.9	1907
December	429.2	1903	94.0	1906

Average of rainfall at Bacolod, Occidental Negros, deduced from the period 1903–1908.

Month	Millimeters.	Month	Millimeters.
January	111.2	July	348.5
February	64.0	August	326.1
March	15.3	September	302.1
April	24.5	October	227.0
May	138.6	November	140.9
June	236.0	December	201.8

Maximum and minimum of temperature for each month of the year at Bacolod, Occidental Negros, deduced from the period 1903–1908.

Month.	Monthly maximum.		Monthly minimum.	
	°C.	Year.	°C.	Year.
January	35.4	1905	15.5	1905
February	35.9	1905	15.1	1905
March	37.8	1905	16.7	1905
April	38.2	1905	19.0	1904
May	37.8	1905	21.5	1908
June	34.4	1906	21.3	1907
July	33.0	1907	20.7	1906
August	32.6	1906	20.3	1907
September	33.9	1904	21.2	1903
October	34.3	1904	21.1	1904
November	33.9	1904	19.2	1906
December	32.6	1904	16.5	1904

Average of temperature for each month of the year at Bacolod, Occidental Negros, deduced from the period 1903–1908.

	°C.		°C.
January	26.0	July	26.6
February	26.0	August	26.0
March	26.9	September	26.7
April	27.8	October	26.8
May	28.4	November	26.4
June	27.4	December	26.3

During the milling season, from November to June, the northeast monsoon blows quite steadily, with few storms and comparatively little rain. Southwest winds prevail throughout the greater part of the rainy season, and, as in other parts of the Islands, a considerable amount of rough weather is experienced, but Negros is so well protected by adjacent islands that very little damage is ever occasioned by storms.

THE SUGAR BELT.

The greater proportion of the sugar of Negros is produced in the so-called sugar belt or coastal plain, which extends from the town of Victorias in the north to the Ilog River in the south, a distance along the west coast of approximately 130 kilometers. The width of this plain from mountains to sea is from 5 to 30 kilometers; however, all of this land is by no means suitable for growing cane. Much of it along the coast is covered by swamps, and the soil in the inland toward the mountains

is often rocky and nearly barren. The sugar belt from north to south may be divided into five important districts, each of which produces annually more than 5,000 metric tons of sugar. These districts comprise the following municipalities and their surrounding land:

1. Victorias, Saravia, Silay, Talisay; 2. Bago; 3. Pontevedra, La Carlota; 4. Binalbagan, Isabela; 5. Ilog, Cabancalan.

It is intended to take up each of these separately, giving whatever data possible regarding the character and composition of the soil, quantity and quality of sugar and cane produced, transportation facilities, and other available facts.

THE EAST COAST.

As has been stated previously, the principal mountain chain running through Negros from north to south lies much closer to the east than to the west coast. In addition to this, a secondary range of foothills extends on this side very nearly to the sea. No great coastal plain exists here, as on the west, but mountains or rugged hills descend abruptly to the strand, leaving only here and there scattered patches of land in the valleys of small streams, where sometimes a few hundred tons of sugar are produced. Exceptions to this rule are the districts of San Carlos in the north and Bais in the south, each located in a sheltered valley of considerable extent, and each producing annually about 5,000 metric tons of sugar. These two localities will be considered together with the five principal districts of the west coast.

OTHER SUGAR-PRODUCING DISTRICTS OF NEGROS.

The seven large districts just mentioned comprise the principal sugar centers of the island. Lying between these, along the west coast are several other municipalities and barrios, each of which yields from 1,000 to 3,000 metric tons of sugar per annum, but these are so isolated by lack of proper land transportation facilities that at the present time they must be considered as separate, comparatively unimportant sections, although with the advent of good roads and modern methods of sugar production many of them will undoubtedly be united to the nearest lying main districts. South of the Ilog River there is a large extent of forest land, mostly hilly, but containing several level plains where, it is stated, sugar cane may be as profitably grown as in any other portion of the island. However, this region is as yet undeveloped and it is impossible to give exact data as to its resources.

HISTORY OF SUGAR PRODUCTION IN NEGROS.

According to R. Echaúz,[2] the history of Negros as a sugar-producing country practically begins with the year 1849, in which year the island, by command of the Spanish governor-general, was placed under the jurisdiction of the religious order of the Recoletos. The rapid development of the industry which at once ensued and continued during the next forty years is attributed to the enthusiastic and untiring efforts of this corporation, ably assisted by the then British vice-consul, Nicholas Loney. Prior to 1849, some sugar was made in Negros, it is true, but only in very small quantities and by the crudest methods, cane being crushed in wooden mills, and the resulting juice boiled down to a sticky mass in small iron kettles over an open fire and sent to the market in small bundles wrapped in the whole leaf of the buri palm. The island was at that time practically unexplored and inhabited for the greater part by semibarbarous tribes of forest people. The following figures are given as illustrating the progress made from 1850 to 1893.

	1850.	1880.	1893.
Inhabitants of the island	30,000	200,000	320,606
Sugar, in piculs	3,000	618,120	1,800,000
Sugar, in metric tons	190	39,096	113,850
Wooden mills	7		
Mills run by steam		59	274
Mills run by water power		17	47
Mills of iron, run by animal power		495	500
Steam plows			3
Tramways (for transportation of cane)			23

RECENT STATISTICS.

During the period from 1893 to 1895 the sugar industry of Negros reached a height of prosperity which it has never again attained. Since then it has suffered so greatly from war and animal diseases that for a time it was practically paralyzed, and, although a slight tendency toward recovery was experienced shortly after the period of greatest depression, the total production of the island has for the past few years remained very nearly stationary, at a figure approximating 60 per cent of the maximum yield in 1893. The following data collected by the Bureau of Internal Revenue for the year 1908 show by municipalities the area of land actually cultivated in sugar, the area of growers' land adapted to such cultivation but not so planted, the area of other land certified by municipal councils as adapted to sugar culture but not planted because of lack of transportation facilities, animals, or capital, and the amount of sugar produced during that year.

[2] Apuntes de la Isla de Negros. Manila (1894), 11.

Statement showing by municipalities the area of land actually cultivated in sugar, the area of growers' land adapted to such cultivation, the area of other land certified by municipal councils as adapted to sugar culture but not planted because of lack of transportation facilities, and the amount of sugar produced during the year 1908.

Municipality.	Number of growers.	Area of growers' land actually cultivated in sugar.	Area of growers' land adapted to sugar culture but not so planted.	Area of other land not planted.	Piculs of 63.25 kilograms.	Metric tons.[a]
Negros Occidental:		*Hectares.*	*Hectares.*	*Hectares.*		
Bacolod	21	794	2,068	1,010	27,846	1,761
Bago	42	2,555	2,871		83,691	5,293
Binalbagan	14	960	1,575		20,500	1,296
Cabancalan	12	774	461	1,000	60,002	3,795
Cadiz Nuevo	32	1,684	2,191	1,000	51,452	3,254
Escalante						
Cauayan				2,000		
Ilog	10	858	396		54,802	3,465
Isabela	29	1,997	1,293	1,500	85,808	5,427
Jimamaylan	19	762	935		34,158	2,160
Hinigaran	14	579	957	500	20,097	1,271
La Carlota	30	1,887	3,046	270	130,023	8,224
Manapla	25	1,386	2,471	1,900	42,750	2,704
Murcia	13	350	1,401	500	18,970	1,200
Pontevedra[b]	17	850	2,957	950	60,075	3,800
Sagay	7	369	343	300	10,907	690
San Carlos	14	2,080	866	500	76,300	4,825
Saravia	27	1,320	1,862	652	55,215	3,492
Silay	64	2,834	5,367	400	124,476	7,873
Talisay	36	1,800	3,621		59,669	3,772
Valladolid	8	187	277	120	7,090	448
Victorias	16	722	2,086	1,812	30,096	1,904
Total	450	24,748	37,044	14,414	1,053,927	66,661
Negros Oriental:						
Ayuquitan				500		
Bacon				75		
Bais	18	1,688	1,157	20	76,509	4,839
Dauin						
Dumaguete	11	130	234	1,000	4,110	260
Guihulugan	1	300			13,000	822
Larena		5				
Lazi				35		
Siquijor (sub-province)				10		
Tanjay	3	150	110	550	11,900	753
Tayasan						
Tolong	1	75		300	2,000	127
Luzuriaga						
Total	34	2,348	1,501	2,490	107,519	6,801

[a] Expressed in nearest whole numbers.
[b] Including La Castellana.

Much interesting information which has heretofore not been available concerning the actual condition of the sugar industry of Negros may be deduced from these figures. Thus, in the whole island there was a total of 484 planters, who controlled in all 65,641 hectares of land adapted to sugar culture, of which 27,096 hectares were actually under cultivation and 38,545 for various reasons left unplanted. In addition there were 16,904 hectares of sugar land left unoccupied principally because of the lack of transportation facilities. During the year there were produced a total of 1,161,446 piculs or 73,462 metric tons sugar. Each planter, then, possessed on a average 135.6 hectares of cultivable sugar land, but planted only 56 hectares of it, allowing the remaining 79.6 hectares to lie idle. He produced from the 56 hectares planted 2,400 piculs, or 151.8 metric tons of sugar. Out of a total of 82,545 hectares of land certified to as being well adapted to the culture of the sugar cane 32.8 per cent was actually being cultivated, 46.7 per cent was owned by sugar growers but not planted, and 20.5 per cent was unoccupied, or at least unused because of lack of transportation facilities, animals, or capital. In considering these figures it should be borne in mind that they refer not to the total area of land comprised by the various municipalities, but to that portion of it, generally a small per cent, which is well known and certified to as being fit for cane growing.

Dividing the total production of sugar by the number of hectares planted, we find that the average yield per hectare throughout Negros is 42.9 piculs, or 2.71 metric tons. This question of the average yield has long been a much-disputed point and one which it has been impossible hitherto to state with accuracy. Depending upon the locality which is visited, it is possible to form estimates which may vary several hundred per cent from the truth, in either direction. I have seen cane fields so sparsely sown and of such poor quality as to produce not more than 10 to 15 piculs (0.63 to 0.95 metric tons) to the hectare, while on the other hand there are well-authenticated cases in the richer districts where fields of several hectares in extent have averaged as high as 200 piculs, or 12.6 metric tons, to the hectare. The average yield for the island is greatly reduced by the comparatively large number of small growers who lack either the resources or the ability properly to care for their cane. I may state from personal observation that on a well-managed plantation—and there are a few such in Negros—the yield per hectare under normal conditions of land actually planted in cane will rarely fall below 60 piculs (3.8 metric tons), and frequently comes nearer 70 piculs (4.4 metric tons); this should hold true in the poorer as well as the richer sections, as the difference in quality of soil is in a measure made up for by the fact that cane grown in the former is as a rule richer in sucrose and is replanted every year on fresh soil, whereas in the latter it is allowed to ratoon until the yield becomes greatly diminished.

VARIETIES OF CANE GROWN IN NEGROS.

As far as I have been able to ascertain, the only variety of cane ever grown here to any considerable extent is the so-called "caña morada," or

purple cane. This appears to have been cultivated in Negros for a very long time, as the "oldest inhabitants" at least do not appear to recollect its introduction. It is entirely different from the white or yellow cane common in Luzon, and was quite possibly imported directly to Negros on or about the time of the occupation of the island by the Recoletos. In appearance it is much like the Louisiana Purple, varying in color according to the conditions of its growth from a comparatively light red to a very dark purple. As will be shown later, this cane is extremely sensitive to changes in environment and climate, varying greatly in composition in different sections of the island, but its natural tendency is apparently toward a slender, rather small growth, high in sucrose and purity and comparatively low in fiber. Aside from this variety, a few fields of black cane, and some scattered specimens of the white or yellow variety, there is practically no other kind of cane to be met with in Negros.

CANE DISEASES AND INSECT ENEMIES.

Up to the present time no serious study has been made of this subject. The planters themselves have no knowledge of any fungus or other disease which has ever attacked the cane, and during my stay in Negros I failed to find any indications of diseased cane which would be apparent to one not a trained plant pathologist.

The only insect enemy recognized by the planters is the so-called "bucan" or "bugan," a grub resembling the larva of the common coconut beetle except that it is smaller. This has been known in Negros for many years, but is not generally thought to do much damage except in certain localities where many ratoons are raised, where considerable loss is sometimes occasioned by its burrowing into and attacking the underground system of the young ratoons, thus stunting the growth of the plant, if not actually killing it.

This is now being made the subject of a separate investigation by the botanical and entomological divisions of the Bureau of Science.

NATIONALITY OF THE PLANTERS.

The haciendas of Negros are owned and managed almost exclusively by Spaniards, Spanish mestizos, or native Visayans. Of other nationalities there are only a few Swiss, one or two Americans, and occasionally a Chinese mestizo. Spanish is the universal language among the hacenderos, and is probably in more common use here than in any other part of the Islands. Practically all of the native planters speak Spanish, while only in exceptional cases is one to be found who understands more than a few words of English.

NATIVE LABOR: DIFFICULTIES, PAST AND PRESENT.

The necessary laborers for taking off a sugar crop are, excepting in the rare instances where a sufficient number live on the hacienda, imported each year, by contract for the season, from the neighboring Islands of Panay and Cebu. They are all Visayans, those on the west coast speaking the Panayano and on the east the Cebuano dialect. Labor is paid for at an average rate of 25 centavos, Philippine currency, per day, with rations furnished by the hacienda, and costing about 15 centavos extra per man each day. This is the commonly accepted wage throughout the island, the extreme limits being 25 centavos without rations and 50 centavos without rations. Complaint is universal over the difficulty of obtaining a sufficiency of labor. This is occasioned largely by the abnormal conditions prevailing in Negros during the milling season, when, because each small planter has his own mill and grinds his own cane, an excessive number of laborers is required for a few months in the year only; during the remainder less than half this number is necessary. As a result, the planter who can not afford to keep on his plantation for the entire year men whom he only needs for the grinding season is forced to arrange with labor contractors to bring the necessary extra men in from other parts of the country, and as an additional inducement to advance 10 to 25 pesos (5 to 12.50 dollars, United States currency) for each man desired. Breaches of faith by contractors after receiving advance money are frequent, and numerous instances are cited where out of twenty or thirty men reporting for work and receiving a month's wages in advance, half have escaped within the week. The planters complain that it is almost impossible legally to compel a man to work, even though payment for his services has been given him in advance and under a written contract. The man, if apprehended, admits the debt and declares his willingness to repay it in cash as soon as he can secure the money, lamenting at the same time his present inability to do so. Since imprisonment for debt is no longer possible, he must be set at liberty to go to some other hacienda and repeat the same process. On the other hand, the custom of giving laborers advance money is such a long-established one that the planter who refuses to do so finds it extremely difficult to secure enough men to carry him through the grinding season. This labor difficulty is so serious throughout Negros, as several planters have informed me, that they annually lose more money in this way than through all other causes combined. Year by year, it is complained, as men find out that they can break contracts and go unpunished, the practice is becoming more prevalent. However, this ambition on the part of the native laborer to obtain money without rendering its due equivalent has not entirely been brought about by American influence, as is sometimes insinuated; this is shown by the fact that even in prosperous times under

the Spanish régime it was the cause of serious complaint. Echaúz[3] treats of this particular phase of the labor problem together with other troubles of the hacendero. His remarks, although somewhat lengthy and poetically expressed, are worthy of quotation as showing that the sugar grower had much the same difficulties to contend with then as now. The following is a free translation from page 82 of this book:

"The planter, compelled by the harsh and imperious law of custom and of lack of capital, a law more forceful and obligatory than any officially sanctioned and published, is at once farmer and manufacturer; he cultivates the fields, and busies himself with making sugar by short and simple methods, operations in field and sugar house during certain months in the year being carried on simultaneously, conditions which force him to pay out enormous sums of money and to borrow at usurious rates. Not until there shall be established central haciendas on extensive estates, until the farmer be allowed to remain farmer and the manufacturer to occupy himself solely with his factory, will the sugar planter prosper as he should, notwithstanding the fertility of our soil, the cheapness of labor, and the large yields obtained here as compared with those in the Peninsula (Spain).

"But these difficulties are as nothing compared to one of greater moment, which most prejudices the farmer's welfare, which, unless an energetic remedy is taken, or a law set forth binding on everyone, will put an end to agriculture in the Island of Negros—the question of laborers.

"This island, for its cultivation, already so intensive, for its progress, ever greater, needs a multitude of laborers. Enough, perhaps, dwell within its boundaries, but will not work, preferring to enjoy the abundance of plains and mountains plentiful with fruit, of rivers and of seas, which for slight effort yield to man his daily sustenance. The lack of laborers on the island makes it necessary to seek them from other provinces.

"The month of September arrives, and the planter gazes with admiration on a bountiful harvest; his complacency is without limit; passing from field to field, he thinks of the number of piculs he is on the point of harvesting, but, in the midst of a state of mind so satisfactory, a doubt assails him, he is perplexed by one thought—laborers are needed—and to remedy this difficulty, thirty or forty thousand pesos are sent off to the Island of Panay. November comes; December, January, and the promises made when he sent off the money are not yet fulfilled. Neither the number of laborers agreed upon nor the pesos advanced to them put in their appearance.

"Twenty or thirty well-clad individuals present themselves at the sugar house, speak with the foremen and express a desire to go to work, because, as they say, they know the planter has a kindly disposition and treats his men well, demanding, at length, after a large amount of talk, from seven to ten pesos apiece, which they need to buy cedulas, pay taxes, or to support their families. The hacendero grasps at this unforeseen opportunity, builds up new hopes on the strength of the reinforcement, and hands over the money, and the surprise comes next day when he finds himself without workmen and without coin. The laborers who presented themselves the day before have disappeared during the night.

"This actually happens in Negros, and there is urgent need of a speedy and efficacious remedy for an evil which, if allowed to spread, may ruin the work of many years. Regulations should be made regarding hours of work, wages which must be paid, rations, voyages, time of stay in each hacienda, but, at the same time, let some guaranty be given to capital, some security to the planter."

[3] *Loc. cit.*

THE PRINCIPAL SUGAR-PRODUCING DISTRICTS OF NEGROS.

SILAY.

In this district may be considered to lie the entire stretch of land extending from the town of Victorias southward to the southern limits of the municipality of Talisay, a district having a length in a direct line of 25 kilometers and varying in width from 5 to 15 kilometers from the seacoast to the hills. Of the four municipalities included therein, Saravia, Silay, and Talisay are most closely connected, being situated in a direct line along the main provincial road, which affords a ready means of intercommunication during the entire year. From Saravia eastward to Victorias the roads are not so good, several small streams are as yet unbridged, and traveling is in the main restricted to the dry season. However, road-building work is progressing steadily, and it is expected that within a short time the provincial highway will have been extended to Victorias. As it is, land-transportation facilities are better in the district around Silay than in any of the other sugar centers of Negros, first, because of the lack of large rivers affording means of communication by water, and, second, owing to the fact that this portion of the island has been settled for the longest time. Here, in the early sixties, were established the first large haciendas founded on capital supplied by Iloilo merchants, and in this section the local sugar industry for a long time made its most rapid advances. Even at the present day this district leads all others in point of total production and in number of plantations, although not in yield of sugar per hectare. The following data regarding sugar land and production in this section in 1908, calculated from the statement of the Bureau of Internal Revenue previously quoted, are, for more ready reference, rearranged here.

Area and production of the Silay district.

	Amount.	
Number of growers in the district, 143.	*Hectares.*	*Per cent.*
Area of growers' land actually cultivated in sugar	6,676	29.7
Area of growers' land adapted to sugar culture but not planted	12,936	57.5
Area of other land adapted to sugar culture but not planted	2,864	12.6
Total available sugar land	22,476	
Average area of land per planter:		
Planted	46.7	
Not planted	90.5	
Total	137.2	
	Piculs.	*Metric tons.*
Total sugar produced	269,456	17,043
Average amount of sugar produced per planter	1,884	119.2
Average yield of sugar per hectare	40.4	2.5

It will be noted, on comparing these figures with those for the entire island, that although each planter in this district possesses a trifle more land than the average grower throughout the island, he produces from it much less sugar—119.2 metric tons, as compared with 151.8, the general average. This is due not so much to a smaller yield of sugar per hectare as to the fact that of the total land owned by sugar planters, a much smaller proportion is each year planted in cane. As in most other places, lack of capital is responsible for much of the idle land, but the trouble here seems to lie largely in the land itself, much of which has become so exhausted through sixty-odd years of continuous cultivation with scarcely any attempt at replenishing its fertility that at the present day it may be relied upon to yield only one crop every two or three years; during the remainder of the time it is allowed to lie fallow.

Below are given analyses of typical soils throughout the district.

The field samples of these and all subsequent analyses were carefully taken with a soil auger, under my personal supervision, and each number represents a composite of from two to five individual samples taken from different parts of a field. The surface soils were taken to a depth of 20 centimeters, except in the relatively few instances where a decided change in composition was apparent at a less depth. The "subsoils," generally a mixture of subsurface and true subsoil, were taken through a stratum of 25 centimeters, commencing at the point where the first noticeable difference from the surface soil was encountered. In cultivated fields this difference occurs as a rule at a depth of from 20 to 30 centimeters, and is fairly easy to detect, long-continued plowing through many years having so thoroughly mixed and altered the top layer that a decided change in composition or texture is noted once the plow line is passed. In spite of many rumors and traditions of "ten-foot" soils in Negros, only a very few instances have occurred where a true subsoil could not be encountered within at least 60 centimeters of the surface. In sampling freshly plowed fields, or fields containing growing cane, a portion of soil from the top of a furrow or row was first scraped away, so that the sample started at about the average level of the field.

The chemical analyses of these soils were made substantially according to the methods of the Association of Official Agricultural Chemists, and results are expressed as percentages of the soil dried to constant weight. All determinations except potash, soda, and "volatile matter" were made by L. A. Salinger and R. R. Williams, of the Bureau of Science.

Mechanical analyses of a large numbers of these soils were made by Mr. Wallace E. Pratt, of the Division of Mines, using the centrifugal method as outlined in Bulletin No. 24, United States Department of Agriculture, Division of Soils. For this work the air-dried samples as prepared for chemical analysis were employed.

Soil analyses, district of Silay.

Soil No.	Nature of soil.	Fine earth.	K_2O.	Na_2O.	CaO.	MgO.	P_2O_5.	N.	Volatile matter.	Remarks.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
50	Surface	97.7	0.06	0.08	0.45	0.42	0.05	0.06	5.31	Hacienda Buen Retiro, Silay. Considered very good sugar land; said to yield about 110 piculs (7.0 metric tons) of No. 1 sugar per hectare. Has been under cultivation for more than fifty years. Does not yield ratoon crop. Surface soil light loam; subsoil at 20 centimeters, yellow sand and clay; at 50 centimeters, nearly all sand.
50 A	Subsoil	98.4	0.07	0.07	0.47	0.36	0.04	0.03	7.35	
51	Surface	96.3	0.05	0.04	0.46	0.48	0.05	0.06	4.66	Hacienda Buen Retiro, Silay. Poor, exhausted land; yield said to be about 35 piculs (2.2 metric tons) per hectare. Has been cultivated more than fifty years. Surface soil in appearance much like No. 50; subsoil at 25 centimeters, white clay mixed with coarse reddish sand and small pebbles.
51 A	Subsoil	92.0	0.04	0.06	0.49	0.50	0.04	0.06	8.21	
52	Surface	97.8	0.03	0.08	0.51	0.25	0.08	0.06	4.14	Hacienda Binonga, La Paz. Exhausted land, hardly worth planting, as yield is very small. Customary to plant every two years, letting land lie idle in alternate years. Subsoil at 20 to 25 centimeters, white clay with coarse reddish sand.
52 A	Subsoil	89.8	0.03	0.04	0.50	0.35	0.03	0.06	8.33	
53	Surface	93.9	0.04	0.11	0.54	0.54	0.06	0.06	5.33	Hacienda of D. Cuenca, Talisay. Fair land; said to yield 60 piculs (3.8 metric tons) per hectare. Subsoil at 20 centimeters, brown clay and coarse reddish sand and pebbles; at 50 centimeters, mostly sand.
53 A	Subsoil	91.9	0.06	0.12	0.52	0.47	0.04	0.06	7.40	
54	Surface	99.0	0.06	0.07	0.50	0.44	0.06	0.09	6.19	Hacienda Tabigui, Saravia. Fair soil; said to yield 100 piculs (6.33 metric tons) per hectare of Number 1 sugar. Cane grows quickly and ripens in eleven months. Formerly a river passed over this field. Surface soil slightly sandy loam; subsoil at 25 centimeters, sand and clay; at 50 centimeters, much sand, but finer than that of Silay.
54 A	Subsoil	95.1	0.04	0.06	0.49	0.36	0.05	0.09	7.23	
55	Surface	97.8	0.04	0.11	0.67	0.55	0.07	0.13	8.02	Hacienda Tabigui, Saravia. "Tierra baja." Heavier soil than No. 55; more clay. Here cane ripens more slowly. Large cane, but can not produce better than Number 3 sugar. Needs thirteen to fourteen months to ripen. Subsoil at 20 to 25 centimeters, fairly stiff, whitish clay with a very little red sand in streaks; clay becomes whiter with increase of depth.
55 A	Subsoil	93.7	0.03	0.13	0.74	0.49	0.11	0.07	8.23	
56	Surface	99.7	0.05	0.08	0.45	0.51	0.06	0.11	8.11	Hacienda Tabigui, Saravia. Intermediate in appearance between Numbers 54 and 55. Cane ripens in twelve months. Subsoil at 15 to 30 centimeters, a mixture of clay and sand.
56 A	Subsoil	99.9	0.04	0.06	0.40	0.40	0.04	0.08	9.86	

Soil analyses, district of Silay—Continued.

Soil No.	Nature of soil.	Fine earth.	K_2O.	Na_2O.	CaO.	MgO.	P_2O_5.	N.	Volatile matter.	Remarks.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
57	Surface	99.9	0.04	0.12	0.76	0.53	0.08	0.19	6.54	Hacienda Toreno; old town, Victorias. Average cane land of this district. Cane ripens in eleven to twelve months. Said to yield 75 piculs (4.75 metric tons) per hectare of Numbers 1 and 2 sugar. Subsoil at 20 to 25 centimeters, whitish clay mixed with reddish yellow sand; at 50 centimeters, nearly all sand.
57 A	Subsoil	100.0	0.03	0.17	0.76	0.63	0.06	0.15	6.21	
58	Surface	99.7	0.04	0.03	0.11	0.14	0.10	0.16	11.88	Hacienda Esperanza, Victorias, new town (Manapla side). Average land of this district, but very poor soil apparently. Surface reddish brown clay; subsoil at 25 centimeters, a little stiffer clay than at surface; some sand.
58 A	Subsoil	99.7	0.03	0.02	0.14	0.13	0.10	0.12	14.90	
59	Surface	99.9	0.07	0.17	0.76	0.68	0.10	0.17	5.29	Hacienda Lucuay, near town of Silay. One of the oldest cultivated lands in this district; said to yield about 90 piculs (5.7 metric tons) of Number 1 sugar per hectare of plant cane. Surface somewhat sandy loam; subsoil at 20 to 25 centimeters, considerable yellow sand; at 50 centimeters, nearly all sand.
59 A	Subsoil	99.9	0.07	0.16	0.73	0.76	0.07	0.15	5.18	

Soil No.	Nature of soil.	Detritus on 1-mm. screen.	Mechanical analyses of samples (5 grams) of material, district of Silay, passing a 1-mm. screen. Samples as prepared for chemical analysis.						
		>1 mm., gravel.	1.0-0.5 mm., coarse sand.	0.5-0.25 mm., medium sand.	0.25-0.10 mm., fine sand.	0.10-0.05 mm., very fine sand.	0.05-0.005 mm., silt.	<0.005 mm., clay.	Total.
50	Surface	2.3	0.74	5.30	20.60	27.94	29.70	15.56	99.84
50 A	Subsoil	1.6	0.74	5.10	19.32	24.04	27.48	23.40	100.08
53	Surface	6.1	3.06	12.50	20.28	20.32	26.86	16.34	99.36
53 A	Subsoil	8.1	2.20	9.72	18.14	19.94	25.02	25.22	100.24
55	Surface	2.2	0.22	0.84	2.91	23.84	58.01	13.55	99.37
55 A	Subsoil	6.3	1.00	2.22	4.05	18.06	59.28	15.26	99.87
58	Surface	0.3	0.55	1.57	5.01	8.56	31.38	52.86	99.93
58 A	Subsoil	0.3	0.37	1.32	5.15	9.64	30.74	52.32	99.52
59	Surface	0.1	0.14	3.50	24.98	36.72	22.02	12.68	100.04
59 A	Subsoil	0.1	0.20	4.10	24.32	34.52	24.02	12.94	100.10

The average composition of the soil in this district, from the above table, is as follows:

Chemical composition.

Nature of soil.	Fine earth.	K_2O.	Na_2O.	CaO.	MgO.	P_2O_5.	N.	Volatile matter.
Surface	98.17	0.05	0.09	0.52	0.45	0.09	0.11	6.55
Subsoil	96.04	0.04	0.09	0.52	0.45	0.06	0.09	8.29

Physical composition.[a]

Nature of soil.	>1 mm., gravel.	1.0-0.5 mm., coarse sand.	0.5-0.25 mm., medium sand.	0.25-0.10 mm., fine sand.	0.10-0.05 mm., very fine sand.	0.05-0.005 mm., silt.	<0.005 mm., clay.	Total.
Surface	2.2	0.94	4.74	14.76	23.48	33.59	22.20	99.71
Subsoil	3.3	0.90	4.49	14.20	21.24	33.31	25.83	99.97

[a] Since a less number of samples were taken for the mechanical analyses, their average is not strictly comparable with that of the chemical analyses.

This soil is, on the whole, decidedly poor in all the elements of soil fertility, with the exception of lime, which is present in a fairly large amount, although not large as compared with other parts of the island. In this case chemical analysis is well borne out by practical experience, as Silay is generally considered to be the poorest of the large sugar districts. The majority of the plantations here are in what might be called a "semi-exhausted" condition; that is, the land through cultivation has reached that stage where it will no longer yield ratoon cane, nor in many cases consistently produce good crops of plant cane without rotation and fertilization. Of course, there is still sufficient fertility left in these soils so that they might go on bearing cane for the next fifty years without becoming completely worn out, even under the present system of cultivation, but the probabilities are that the yield would diminish steadily until finally they would not be worth cultivating. By this is not meant that these soils are necessarily doomed eventually to become barren. Enormous crops of sugar are, in other countries, raised on lands but little better than these. With more careful cultivation, the consistent return to the fields in the shape of bagasse ash and animal manure of the potash, phosphoric acid, and nitrogen taken from them, together with eventual green manuring and rotation, there is no reason why these lands should not go on producing good crops of cane almost indefinitely and with little need of recourse to artificial fertilizers. The point is that they, unlike some other parts of Negros, have reached that stage where they no longer stand abuse.

Individually, very little difference can be detected in these soils. Chemical analysis at its best gives only a very rough approximation of a soil's productive power, as, owing to its physical condition or the state of combination of its constituents, an apparently very poor soil may have available sufficient plant food to produce much larger crops than one which, chemically considered, is its superior. Take numbers 50 and 51, for instance: Both are from the same hacienda, both have been cultivated for over fifty years, and in chemical composition they are very nearly identical, yet number 50 is said to produce more than three times as much sugar per hectare as number 51. Numbers 57, 58, and 59 are decidedly high in nitrogen, for this district. They have very probably been treated with animal manure.

All these samples were obtained so late in the grinding season that I had no opportunity personally to examine the cane produced in this region, and the figures given as to the quality and quantity of sugar produced from the different soils are simply approximations made by the planters themselves. The general tendency in such cases is toward over-, rather than underestimation.

The quality of sugar produced in Silay is somewhat better than in most other districts, it being largely "No. 1" and "No. 2." This in itself is considered an indication of a not too fertile soil, since the smaller canes produced yield normally a juice of higher purity and, by the local process of manufacture, a better sugar than the more luxuriantly grown canes of richer districts.

For shipment to Iloilo the sugar is handled in bull carts to the nearest lorcha landing on the coast at a cost of from 5 to 25 centavos a picul, 0.79 to 3.96 pesos a metric ton, according to distance. As Silay is situated nearer to Iloilo and is more conveniently located than other sugar centers, the freight rate is correspondingly lower, averaging 15 centavos per picul, or 2.38 pesos per metric ton.

BAGO.

Southward, along the provincial road from Talisay through Bacolod, the capital of the Province of Occidental Negros, the land becomes gradually poorer in quality, and this section is, at present, of relatively little importance as a sugar producer, although in former times it was quite extensively and profitably cultivated. The greater part of the land around Bacolod, probably less fertile in the beginning, is much further advanced along the road to complete worthlessness than that of Silay, and much of it has already passed the stage where it will yield returns sufficient to pay for planting in cane. From Bacolod, extending nearly to the town of Bago, a distance of some 20 kilometers, a strip of land is found which in the main is almost absolutely

barren and unfit for cultivation of any kind. A typical analysis of this kind of soil is included under those of Bago.

The sugar soils of Bago are restricted to a narrow strip of land 2 or 3 kilometers in width, along the Bago River from its mouth to its junction with the Malacandang River, near the hacienda San Juan del Monte, a distance from the coast of 12 kilometers; thence spreading out into the larger, but more rolling, triangular section between the Bago and the Malacandang Rivers, comprising the barrio of Maao, and on up to the foot of the mountains. The distance in a direct line from the seacoast to the hacienda Progreso, farthest to the interior of the district, is 26 kilometers. The Bago River is navigable by sugar lorchas at high tide for 7 kilometers up to the hacienda Lumañgub, although two days are generally required for the trip. A sand bar at the mouth of the river prohibits entrance except just at the height of the tide, and by the time this has been passed the water has again fallen so that it is necessary to wait twenty-four hours before proceeding up the river. Haciendas lying inland from Lumañgub are obliged to bring their sugar down in bull carts to this point for shipment to Iloilo; and this at considerable expense, owing to roads which, while passable in dry weather, are, after a little rain, absolutely useless. The cost of transporting sugar by bull cart from Progreso to the lorcha landing at Lumañgub is 30 centavos per picul, or 4.75 pesos a metric ton. Adding 20 centavos more as the cost of shipping to Iloilo, this makes a total of 50 centavos per picul, or 7.90 pesos a metric ton, for transportation charges alone, about three-fourths the cost of freight from Iloilo to New York. Owing to the excessive cost for transportation, sugar growing has been abandoned as profitless in many of the plantations of the interior of the Bago district, although, in other respects, sugar may be produced at less expense here than in the majority of other parts of the island. The better cultivated lands, therefore, are confined to the narrow strip adjoining the navigable portion of the Bago River. The best lands lie close along the river on the north bank, where the soil is an alluvial, more or less sandy loam, becoming heavier with increasing distance from the river, until, at about 1 kilometer, low land made up of heavy clay is encountered. This, because of lack of drainage, is very sticky and difficult to work properly; it is therefore used chiefly for rice culture. A kilometer farther on, the land rises again, and from here to Bacolod lies the rocky, barren region previously mentioned. South of the river conditions are much the same—about a kilometer of good sugar land, shading off gradually into heavy clay and paddies, but rising again, after a few kilometers, to form the municipalities of Valladolid and La Carlota.

The following data give the area of land and production of sugar in Bago during 1908:

Area and production of the Bago district.

	Amount.	
Number of growers in the district, 42.	*Hectares.*	*Per cent.*
Area of growers' land actually cultivated in sugar	2,555	47.1
Area of growers' land adapted to sugar culture but not planted	2,871	52.9
Total available sugar land	5,426	
Average area of land per grower:		
Planted	60.8	
Not planted	68.4	
Total	129.2	
	Piculs.	*Metric tons.*
Average of sugar produced	1,993	126.1
Average yield of sugar per hectare	32.8	2.07
Total sugar produced	83,691	5,293

The average grower of this district, while owning somewhat less sugar land than is the general average for Negros, has considerably more of it planted in cane. The decidedly low yield per hectare of land is brought about by inefficient cultivation because of lack of capital in many haciendas. In this district, moreover, the yield per hectare computed from these figures is probably much further from the true average yield than in other localities. The year 1908 was a decidedly poor one for Bago, while, on the contrary, a considerably greater amount of land had been planted for the year 1909, as will be shown by the following figures:

Total yield of sugar.

	Piculs.
1907	91,775
1908	83,691
1909 (estimated)	103,620

The only figures available over the whole island for calculating the yield per hectare were the area of land planted for 1909 and the total production in 1908, which, taken as a whole, give fairly correct results, although a trifle low, but in the case of Bago, in particular, they lead to an erroneous conclusion. Assuming the estimated yield for 1909 to be the true one, the yield per hectare in Bago would be 40.6 piculs, a figure more nearly approximating that for the whole of Negros. In addition, some of the figures reported from Bago were decidedly irregular, due probably to some misconception on the part of the planters as to the information desired. The Government was obliged to depend for this information almost entirely upon statements made by the planters themselves, and I know of at least one instance where the yield per hectare of land planted, calculated from a planter's statement, averaged only 20 piculs, whereas I have positive knowledge that ordinarily it would run nearly 60.

In quality, the sugar produced here is, as a rule, superior. According to analyses of cane, quoted later, it should be nearly all "No. 1," but, owing to poor work in the sugar houses and often to lack of facilities for cutting cane at the proper time, a considerable amount of low-grade sugar is also made.

The following are analyses of representative Bago soils, taken throughout the district from near the coast up to the hacienda farthest inland.

Soil analyses, district of Bago.

Soil No.	Nature of soil.	Fine earth.	K_2O.	Na_2O.	CaO.	MgO.	P_2O_5.	N.	Volatile matter.	Remarks.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
14	Surface	98.4	0.11	0.08	0.48	0.25	0.10	0.09	9.71	Hacienda San Esteban, Maliñgin; best land near Bago River. Light loam, a trifle sandy. This field was treated with lime in 1908. Said to yield about 75 piculs (4.75 metric tons) of No. 1 sugar per hectare. Subsoil begins at a depth of from 40 to 60 centimeters; a mixture of reddish clay and sand, sandier as it becomes deeper.
14 A	Subsoil	98.3	0.08	0.10	0.50	0.36	0.11	0.06	8.63	
15	Surface	98.8	0.08	0.08	0.40	0.38	0.07	0.10	8.91	Hacienda San Esteban, Maliñgin; poor land, about 1 kilometer from river. Light loam, white when dry. Canes growing here are very small and sparsely grown. Subsoil begins at from 15 to 35 centimeters, a stiff clay mixed with coarse yellow sand in streaks; at 60 centimeters, white, very stiff clay, with rather more streaks of sand.
15 A	Subsoil	98.5	0.08	0.08	0.41	0.43	0.06	0.08	10.48	
16	Surface	99.7	0.10	0.10	0.80	0.48	0.11	0.08	7.64	Hacienda Alegria. This is said to be the richest land in the district of Bago. Samples taken about 1 kilometer from the river. Not the best field in the hacienda, but very good; said to yield 125 piculs (7.9 metric tons) of No. 1 sugar per hectare. Light, almost sandy loam; subsoil of clay and sand begins at from 20 to 60 centimeters, although in spots the surface soil continues practically unchanged down to 80 centimeters.
16 A	Subsoil	99.7	0.11	0.07	0.63	0.56	0.11	0.06	8.40	
17	Surface	99.9	0.12	0.05	0.36	0.39	0.08	0.09	8.94	Hacienda Lumañgub. Good cane land, about 200 meters north of Bago River. Said to yield about 100 piculs (6.33 metric tons) per hectare. Subsoil at about 35 centimeters, fairly stiff clay with some sand, sand increasing with depth.
17 A	Subsoil	98.8	0.12	0.05	0.38	0.43	0.08	0.08	10.21	
18	Surface	97.4	0.09	0.07	0.37	0.49	0.08	0.08	7.39	Hacienda Santo Domingo, south side of Bago River. A good average cane land; said to yield about 85 piculs (5.38 metric tons) per hectare. Soil is a light powdery loam, very light colored when dry; subsoil at 25 centimeters, whitish clay with coarse yellow sand in streaks.
18 A	Subsoil	98.3	0.10	0.08	0.55	0.28	0.10	0.06	10.47	

Soil analyses, district of Bago—Continued.

Soil No.	Nature of soil.	Fine earth.	K_2O.	Na_2O.	CaO.	MgO.	P_2O_5.	N.	Volatile matter.	Remarks.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
19	Surface	99.8	0.11	0.13	0.62	0.31	0.13	0.09	8.36	Hacienda San Juan del Monte; best field in the hacienda. 300 meters from river. This field was once measured and the sugar made from it weighed. It is said to have yielded 116 piculs (7.35 metric tons) per hectare. Surface soil light loam; subsoil at about 35 centimeters, brownish clay and yellow sand well mixed.
19 A	Subsoil	99.8	0.12	0.10	0.66	0.21	0.11	0.07	8.72	
20	Surface	94.2	0.07	0.09	0.35	0.36	0.07	0.07	6.25	Hacienda San Juan del Monte; worst land, 1 kilometer from river, not planted this year. Last season yielded about 50 piculs (3.16 metric tons) per hectare. Rather stiffer soil than No. 19. Owner says that after a rain this field can not be plowed for three days, while No. 19 can be plowed the next day. Subsoil mostly very stiff clay, wet even in dry weather; below 50 centimeters, some gravel.
20 A	Subsoil	92.3	0.06	0.07	0.42	0.33	0.03	0.05	7.73	
21	Surface	97.8	0.28	0.12	0.58	0.37	0.33	0.18	8.66	Hacienda Lumangub. Virgin soil, planted for the first time two years ago. Originally an old sugar mill on this spot. Cane grows very large and luxuriantly here, but nearly all fallen down and yields a very poor quality of sugar. Soil a light loam, inclined to be sandy; subsoil at 60 centimeters, very little difference from surface, perhaps a trifle more clay.
21 A	Subsoil	99.8	0.27	0.10	0.45	0.24	0.16	0.06	7.72	
22	Surface	98.2	0.08	0.02	0.08	0.07	0.09	0.07	14.20	Hacienda Zaragoza. Red clay, said to be poor soil for cane, as it grows large but watery. Subsoil at 25 centimeters, stiff red clay, which continues down at least 2 meters.
22 A	Subsoil	98.4	0.07	0.02	0.10	0.07	0.06	0.03	14.19	
23	Surface	98.0	0.07	0.05	0.24	0.08	0.05	0.11	9.15	Hacienda Zaragoza. White clay, near river, said to be poor soil for cane. Has been planted only to rice. Subsoil at 10 centimeters, very stiff white clay.
23 A	Subsoil	98.4	0.10	0.08	0.55	0.02	0.07	0.06	11.11	
24	Surface	98.9	0.16	0.07	0.20	0.01	0.07	0.16	12.20	Hacienda Progreso. High land, best cane soil, said to yield Nos. 1 and 2 sugar. Soil light loam, slightly yellowish tinge and many stones. This hacienda is the farthest interior, toward the mountains, in the Bago district. Subsoil at about 25 centimeters, brownish clay and sand; below 60 centimeters, some gravel.
24 A	Subsoil	99.2	0.14	0.07	0.19	0.09	0.10	0.10	11.93	
25	Surface	99.7	0.15	0.03	0.19	0.06	0.14	0.11	14.80	Hacienda Progreso. Lower land, but much the same general appearance as number 24. Said to yield much cane, but a poor quality of sugar, No. 3 and "corriente."
25 A	Subsoil	99.7	0.15	0.03	0.15	0.02	0.13	0.09	13.20	

Soil analyses, district of Bago—Continued.

Soil No.	Nature of soil.	Fine earth.	K_2O.	Na_2O.	CaO.	MgO.	P_2O_5.	N.	Volatile matter.	Remarks.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
26	Surface	99.5	0.17	0.07	0.21	([a])	0.07	0.15	11.62	Hacienda Begonia. Soil much the same in appearance as numbers 24 and 25. Said to yield Nos. 2 and 3 sugar.
26 A	Subsoil	99.6	0.13	0.08	0.21	0.02	0.07	0.09	11.72	
27	Surface	99.2	0.06	0.10	0.52	0.24	0.03	0.05	4.39	Hacienda Consorcia, 4 kilometers north of the town of Bago on Bacolod road. Exhausted soil, yield very small, probably not more than 15 piculs (0.95 metric ton) sugar per hectare. Soil is a light sandy loam; subsoil at 25 centimeters, nearly all sand with a little reddish clay; at 80 centimeters, sand and gravel.
27 A	Subsoil	99.2	0.03	0.12	0.56	0.31	0.03	0.05	4.62	
28	Surface	97.0	0.03	0.03	0.30	0.21	0.06	0.06	11.30	Sample of poor land about 2 kilometers north of Bago River. Stony and full of gravel; has never been cultivated. Subsoil 15 centimeters, slate-colored clay.
28 A	Subsoil	97.1	0.02	0.06	0.38	0.03	0.03	0.05	12.11	

[a] Trace.

Soil No.	Nature of soil.	Detritus on 1-mm. screen.	Mechanical analyses of samples (5 grams) of material, district of Bago, passing a 1-mm. screen. Samples as prepared for chemical analysis.						
		>1 mm., gravel.	1.0–0.5 mm., coarse sand.	0.5–0.25 mm., medium sand.	0.25–0.10 mm., fine sand.	0.10–0.05 mm., very fine sand.	0.05-0.005 mm., silt.	<0.005 mm., clay.	Total.
14	Surface	1.6	1.36	5.50	12.72	22.10	32.30	25.76	99.74
14 A	Subsoil	1.7	1.68	6.94	14.78	16.24	32.64	27.04	99.32
15	Surface	1.2	1.36	5.68	9.92	17.00	39.46	26.32	99.74
15 A	Subsoil	1.5	1.76	5.94	10.64	14.08	38.52	29.26	100.20
16	Surface	0.3	0.42	3.40	13.58	26.58	35.64	20.12	99.74
16 A	Subsoil	0.3	0.34	2.60	14.76	27.00	37.92	16.56	99.18
17	Surface	0.1	0.26	2.18	9.20	18.82	40.40	28.64	99.50
17 A	Subsoil	0.2	0.22	2.34	12.10	20.12	39.74	24.84	99.36
18	Surface	2.6	1.74	4.20	6.54	19.74	43.42	23.80	99.44
18 A	Subsoil	1.7	1.76	2.46	8.08	19.84	40.78	27.26	100.18
19	Surface	0.2	0.16	1.08	11.76	35.58	33.50	18.34	100.42
19 A	Subsoil	0.2	0.04	0.72	14.94	34.82	37.62	11.78	99.92
21	Surface	2.2	0.50	2.28	14.10	36.62	35.62	10.88	100.00
21 A	Subsoil	0.2	0.04	0.78	19.46	35.50	32.14	12.06	99.98
24	Surface	1.1	2.30	10.78	14.16	13.06	29.38	30.36	100.04
24 A	Subsoil	0.8	2.12	7.42	10.10	9.52	31.28	39.66	100.10
25	Surface	0.3	1.28	5.12	8.40	11.76	38.44	35.26	100.26
25 A	Subsoil	0.3	0.60	2.84	8.72	8.88	33.20	46.04	100.28
27	Surface	0.8	5.94	30.32	26.62	11.76	12.28	13.34	100.26
27 A	Subsoil	0.8	3.94	26.52	26.36	10.52	15.22	17.56	100.12

These soils average in composition as follows:

Chemical composition.

Nature of soil.	Fine earth.	K_2O.	Na_2O.	CaO.	MgO.	P_2O_5.	N.	Volatile matter.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Surface	98.43	0.11	0.07	0.38	0.25	0.10	0.10	9.57
Subsoil	98.47	0.11	0.07	0.41	0.23	0.07	0.07	10.08

Physical composition.

Nature of soil.	>1 mm., gravel.	1.0–0.5 mm., coarse sand.	0.5–0.25 mm., medium sand.	0.25–0.10 mm., fine sand.	0.10–0.05 mm., very fine sand.	0.05–0.005 mm., silt.	<0.005 mm., clay.	Total.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Surface	1.0	1.53	7.05	12.70	21.30	34.04	23.28	99.91
Subsoil	0.8	1.25	5.86	13.99	19.65	33.91	25.21	99.86

Although not of a high degree of fertility, they are considerably better than those of Silay, especially as regards potash, and they may be classed as thoroughly dependable sugar soils where plant cane alone is to be grown. There is apparently not a sufficient excess of readily assimilable plant food present in them to render ratooning very profitable, although this is done to a very limited extent, especially in the newer lands. The Bago soils carry less lime than those of any other part of Negros, and this fact, in the clay soils at least, probably accounts for the increased difficulty experienced in cultivating them, as they have a tendency when wet to become very sticky and hard to plow; and if plowed while wet they clump together into compact masses which, once dry, are very difficult to break up. As in other districts, analytical differences between so-called good and poor soils are comparatively slight. However, once having established a normal type of soil for a certain district, the relative value of any other soil from the same district may be predicted with some degree of accuracy, provided its physical conditions are at the same time known.

For example, numbers 14 and 15, a "good" and a "bad" soil from the same hacienda, are very much alike chemically, number 14 being very slightly superior in percentage of potash, lime, and phosphoric acid. The chief difference lies in the fact that the subsoil of number 15, fairly close to the surface, is made up of very stiff clay, with only a little coarse sand in streaks, which does not afford sufficient drainage, while that of number 14 begins well below the plow line, and is rather more open in texture.

Chemical analysis shows to better advantage in the case of numbers 19 and 20, samples taken from the best and from the worst field in the same plantation,

number 19 being noticeably superior in every constituent, and especially so as regards lime. Of course, the greater permeability of number 19 has much to do with its superiority, but this difference in physical characteristics is probably brought about to some extent by the larger amount of lime which number 19 carries, the value of lime in a soil being due not so much to the nutriment it affords a plant as to the beneficial effect it has on the physical character of the soil itself, keeping it light and porous, and, in the case of a heavy clay, preserving its tilth by acting as a colloid precipitant and destroying its tendency to form a plastic mass.

The general average of the soils from Bago, as given above, may be taken as just about the normal type for this district from a chemical point of view, anything running much below this in potash, lime, phosphoric acid, and nitrogen being in all probability not very productive. Numbers 27 and 28, characteristic types of the poor land between Bago and Bacolod, are practically valueless for cane growing, as may readily be seen from their analyses. Number 21 is a curious example of a soil which is considered to be too rich for cane. This particular field was, in former times, the site of an old sugar mill, with its surrounding "plaza" for sun drying bagasse, and the comparative richness of the soil here is undoubtedly due to the bagasse ash, scums, trash, etc., which such a place in time accumulates. Quite recently the old sugar house was torn down and the land planted for the first time in cane. This soil, while very much richer than any other in Bago, is not superior to good cane soils from other districts of Negros except in its phosphoric acid content, and, chemically speaking, there is *a priori* no reason why it should not produce a good quality of sugar. Mechanical analysis shows it to be made up largely of very fine sand and silt, with relatively little clay, a condition tending toward rapid growth, but a less sweet cane. The cane found growing here will be considered later under "Other varieties of cane grown in Negros," as, although it really belongs to the common purple or native variety, its composition is so different from that ordinarily grown in Bago that to include it in the table of analyses of canes grown in this vicinity would considerably alter their general average.

ANALYSES OF CANE FROM THE DISTRICT OF BAGO.

The method employed in sampling and analyzing cane from this and other districts was practically the following:

Twenty canes were collected from a field at the time its soil was sampled, five, as a rule, being cut from individual stools growing near the spots where each of the four samples of soil was taken. No especial care was taken except as nearly as possible to select representative samples in regard to size and appearance of the canes growing in each location. Dead and noticeably immature specimens were, of course, rejected. The sample of twenty canes was carried to the laboratory and reduced to a workable bulk by quartering, the upper fourth of the first cane, the second fourth of the second cane, etc., being reserved for analysis, so that the final sample consisted of twenty pieces of cane, five each from the different quarters. These were then weighed and passed through a small hand mill, by which an extraction of about 70 per cent was obtained. The resulting bagasse was weighed and the juice determined by difference, after which juice and bagasse were analyzed separately and the results calculated to percentages on the entire cane.

Cane analyses, district of Bago.

No.	Remarks.	Average weight per cane.	In cane. Sucrose.	In cane. Fiber.	In juice. Brix.	In juice. Sucrose.	In juice. Quotient of purity.	In juice. Reducing sugar.
		Kilos.	*Per ct.*	*Per ct.*		*Per ct.*	*Per ct.*	*Per ct.*
20	Canes taken at random as they are brought to the mill, hacienda Lumañgub; should yield "No. 1" Sugar	0.96	16.55	10.05	20.41	19.28	94.45	0.26
21	Plant cane from soil number 14, hacienda San Esteban, Maliñgin; fifteen months old	0.82	17.19	9.39	21.24	19.64	92.94	0.39
22	Plant cane, twelve months old, from soil number 15, hacienda San Esteban. This field very sparsely grown and canes quite small	0.66	17.04	10.10	21.14	19.64	92.92	0.40
23	Plant cane, twelve to thirteen months old, from soil number 16, hacienda Alegria; best land in the district. Canes rather slender, but of good size; will yield up to 8 metric tons of "No. 1" sugar per hectare	1.07	16.79	10.43	21.30	19.27	90.40	0.66
24	Plant cane fourteen months old, from soil number 17, hacienda Lumañgub	1.10	17.36	9.48	21.38	19.76	92.45	0.51
25	Plant cane twelve months old, from soil number 18, hacienda Santo Domingo	1.03	16.47	9.96	20.43	18.88	92.41	0.63
26	Plant cane fourteen months old, from best soil number 19, hacienda San Juan del Monte	1.09	16.54	8.95	20.19	18.69	92.62	0.63
28	Plant cane, twelve months old, from hacienda Progreso, soil number 24. Said to yield "No. 1" and "No. 2" sugar	1.24	16.30	10.00	20.88	18.67	89.43	1.22
29	Plant cane, twelve months old, from soil number 25, hacienda Progreso. Canes large, but have fallen down badly; said to yield "No. 3" to "corriente" sugar	1.40	13.34	8.48	17.58	14.88	84.63	1.22
31	Plant cane from poor soil, number 27, hacienda Consorcia. Canes twelve months old	0.58	16.47	11.18	20.34	19.26	94.71	0.29
	Average	1.00	16.41	9.80	20.49	18.80	91.70	0.62

A feature of the canes from Bago, which will at once be noted from the foregoing analyses, is their remarkable uniformity of composition, especially those from the lower portion of the district. Among eight different samples from different fields and plantations, the greatest difference between highest and lowest sugar content of the cane is less than 1 per cent. Even number 31, from the very poor soil along the Bacolod road, varies from the others only in its larger percentage of fiber, this undoubtedly being brought about by the dry and arid nature of the soil in which it grows. The uniformity of cane here is caused largely by the fact that the soil is not sufficiently fertile to make ratooning of common occurrence, so that practically all is cane planted from

tops, and there is sufficient land uncultivated to allow each field to become fully ripe before cutting, even if it has to lie over the next year without planting. Soils poorer than the average seem to exert an influence solely on the size of canes produced and the thickness of their growth. Examples of this are numbers 22 and 31, grown in soils numbers 15 and 27, respectively. In addition to being not much over half the average weight of the majority, these canes are much fewer in number to the hectare.

The newer, richer soils of the upper Bago district tend to produce a cane of wider variation in composition, as is shown by numbers 28 and 29, it being on the whole rather poorer in sucrose, although the cane itself is considerably larger. The reducing sugar content of the two samples analyzed, coming from the upper district, was about twice that found lower down, this being in part due to the fact that these larger canes might not have had time to ripen fully, although it was stated that they were twelve months old, and, in a lesser degree, to bad roads and poor means of transportation causing a delay of a day and a half between cutting and analyzing the cane. For the latter reason it was not found practicable in the limited time at my disposal to investigate more thoroughly the upper Bago region.

Taken on an average, canes from the district of Bago are characterized by a high percentage of sucrose, relatively much less fiber than are those lower down, and an extremely high purity. Of course, the purity is somewhat exaggerated by the fact that the juice was expressed by a mill of comparatively little power. The residual juice left in the cane might run from 3 to 4 per cent lower in purity. Such cane as this would be considered almost ideal for a modern mill. The soft fiber, small in amount, would allow the expression of the greater part of the juice in the crusher and first mill, while, because of the richness and high purity of the juice itself, it would allow of dilution to such an extent that enough maceration water could be used so that only a trifling amount of sugar should be lost in the bagasse from the third mill. In fact, I very much doubt if there are to be found, in any part of the world, canes more admirably adapted for yielding good results in milling. From a purely agricultural standpoint such canes are somewhat less desirable. Grown under normal conditions they are by no means large, and, when planted in new or extra fertile soil, have a tendency, because of their low-fiber content, to fall down badly and ripen slowly or not at all. They are also quite sensitive to drought, lack of moisture affecting their size more than their composition. Because of their tenderness and extreme richness they might also, theoretically at least, fall an easy prey to diseases and to insect pests, although of these, fortunately, we thus far have little record.

The general characteristics of high sucrose, low fiber, and high purity are by no means confined to canes growing in the Bago district, but, as will be shown in subsequent analyses, hold good to a greater or less extent over the entire island, those from Bago being somewhat

more uniform in these qualities than is the case in some other districts, but varying little from the general average.

PONTEVEDRA-LA CARLOTA.

This district, the second largest in the island, which includes all the territory lying around and between the above-named municipalities and extending south and east up to and including the barrio of La Castellana, is situated just south of Bago and separated from it along the coast by the municipality of Valladolid, further inland by a section of low rice land along the San Enrique River. La Carlota itself, the principal town in the district, is 10 kilometers inland and lies to the north of most of the haciendas. Transportation for passengers and mail from Iloilo is effected by way of Pulupandan, with which town a steamship service thrice a week is maintained, the voyage requiring only four or five hours. From Pulupandan south along the coast through Valladolid to San Enrique a fairly good road is encountered, but from there inland to La Carlota it can hardly be called a road, except in the dry season.[4] The whole journey by quilez, drawn by a bull, from Pulupandan to La Carlota, a distance of about 25 kilometers, consumes from five to six hours, and costs, according to the nationality of the passenger, from 5 to 10 pesos.

The sugar from this district is shipped by lorcha to Iloilo, either from the landing in the San Enrique River or from that of Pontevedra, 4 kilometers south, at the mouth of the Candaguit River. From the latter point an animal-power tramway runs directly inland for a distance of 8 kilometers to the haciendas Carmen and Carmen Chica, receiving sugar not only from these two but from many others in the southern part of the district as far as La Castellana. A similar tramway, from the landing at San Enrique through the haciendas Caridad, Candaguit, and Fé to the town of La Carlota, transports sugar and freight for the populations lying more to the northward.

Topographically, the district of Pontevedra-La Carlota is somewhat similar to that of Bago, being quite narrow near the coast and gradually spreading out into a triangular-shaped section extending 20 kilometers inland to the foothills, where it is about as broad as it is long. However, there is here no navigable river as in Bago. No cane is grown at the present time directly along the coast. A strip of from 3 to 4 kilometers here, which is now chiefly marsh land, was formerly planted much nearer to the sea, but cultivation has gradually been driven back by the increasing inroads of salt water. It is quite possible that much of this abandoned land might be reclaimed by an efficient system of drainage.

[4] Such was the condition in 1908–9. Since that time much work has been done on the roads of this district, and they have been so improved that it is stated that a regular automobile service has been inaugurated between Pulupandan and La Carlota.

Farther to the inland, for some 10 kilometers, the country is fairly level, and here are to be found the greater number of the haciendas. East of the town of La Carlota the country becomes more rolling in character, and is so much broken by hills and small streams that only a very small proportion of the part farthest to the interior of the district is suitable for cultivation.

Area and production of the Pontevedra-La Carlota district (1908).

	Amount.	
Number of growers, 47.	*Hectares.*	*Per cent.*
Area of growers' land planted in sugar cane	2,737	27.5
Area of growers' land suited to cane culture but not planted	6,003	60.3
Other land suited to cane culture but not planted	1,220	12.2
Total sugar land	9,960	
Average amount of sugar land in hectares owned by each grower:		
Planted	58.2	
Unplanted	127.7	
Total	185.9	
	Piculs.	*Metric tons.*
Average amount of sugar produced by each grower	4,045	255.8
Average amount of sugar produced per hectare planted	69.5	4.39
Total sugar produced	190,098	12,024

In point of production and total area of available sugar land this district is second only to Silay and far surpasses the latter in yield per hectare. In this point, indeed, La Carlota gives better results than the majority of other sections of Negros, the average yield of 69.5 piculs per hectare of land planted being very nearly what might be expected from fairly good sugar soil on any well-managed plantation. The larger yield in this locality may be attributed partially to the soil, which is decidedly richer here than in either Bago or Silay, and also largely to the fact that in La Carlota the haciendas are, as a rule, of greater extent and less handicapped by lack of capital, a number of them being owned or financed by business houses of Iloilo. Moreover, of the total sugar land available a less percentage is reported as actually planted than in any other district, a greater proportion of the yearly crop thus coming from fresh land, and this not on account of poor soil, but more probably because of inadequate milling facilities to take care of a larger crop. Some ratoon cane is grown here, more particularly in the interior, where, on new soils, the first planting is said to yield watery cane and a poor quality of sugar, but the great majority of the haciendas must replant each year.

Back in the foothills at the base of Mount Canlaon, 10 kilometers from La Carlota, lies the so-called "Granja Modelo"[2] or model farm, established for experimental purposes by the Spanish Government, containing 80 hectares of good sugar land. Much benefit to the sugar

industry of the island might have resulted from this station, as it is said to have been at one time very well equipped for experimental work, but during the late war it suffered so severely at the hands of zealous but unscientific *insurrectos* that it has never since recovered.

Following are analyses of soils which represent fairly well all the land lying between La Granja and Hacienda Carmen:

Soil analyses, district of Pontevedra-La Carlota.

Soil No.	Nature of soil.	Fine earth.	K_2O.	Na_2O.	CaO.	MgO.	P_2O_5.	N.	Volatile matter.	Remarks.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
1	Surface	96.4	0.27	0.29	0.78	0.39	0.23	0.19	11.32	La Granja Experiment Station. Samples taken from a cane field in the west part of the hacienda. Subsoil from a depth of 25 centimeters down to 50 centimeters; at 75 centimeters, much gravel.
1 A	Subsoil	98.8	.29	.17	.62	.61	.20	.10	10.22	
2	Surface	86.7	.12	.39	1.95	.66	.35	.34	12.70	La Granja. Taken from an abandoned cane field said to be poor soil.
2 A	Subsoil	87.9	.12	.39	2.21	.68	.30	.28	11.60	
3	Surface	83.6	.18	.22	.80	.52	.17	.19	11.41	La Granja. A good cane soil. Second and third year ratoons growing here. Subsoil is a mixture of clay and sand with some gravel.
3 A	Subsoil	82.2	.17	.23	.84	.26	.15	.10	10.29	
4	Surface	87.7	.18	.34	1.64	.55	.40	.30	11.24	La Granja, experimental plot. Cane is said to grow very large here, but poor in sugar. Said to have been fertilized in past years, but to what extent is not known.
4 A	Subsoil	58.2	.15	.40	1.77	.74	.29	.19	9.84	
5	Surface	96.5	.13	.13	.51	.23	.15	.13	9.65	Hacienda Carmen Chica. Said to be a very good soil, yielding Nos. 1 and 2 sugar. Subsoil a mixture of white and red clay; at 65 centimeters, gravel.
5 A	Subsoil	93.4	.13	.15	.49	.28	.12	.08	9.40	
6	Surface	95.7	.10	.16	.52	.18	.07	.09	7.88	Hacienda Carmen Chica. Best cane land ("tierra baja"). A selected sample from same field as number 5. Subsoil white clay mixed with much of the black surface soil and some sand.
6 A	Subsoil	90.2	.11	.28	1.06	.12	.08	.05	8.16	
7	Surface	91.8	.09	.12	.55	.17	.09	.14	10.27	Hacienda Carmen Chica. Called poor soil ("abo abo"). Surface soil from 15 to 30 centimeters deep; subsoil clay and sand; at 50 centimeters, much sand (and water in some parts).
7 A	Subsoil	87.5	.10	.19	.64	.09	.10	.08	8.50	
8	Surface	98.1	.10	.08	.52	.11	.06	.12	8.99	Hacienda Carmen. Good soil yielding No. 1 sugar. Surface about 15 centimeters deep; subsoil white clay and sand; strike a layer of sand at 60 centimeters.
8 A	Subsoil	98.9	.15	.27	.53	.23	.06	.08	11.50	
9	Surface	96.4	.18	.24	.67	.22	.19	.23	12.20	Hacienda Carmen. When fertilized, yields very large crop but not very pure juice. Two years ago this field was not planted, but used as a pasture for sheep and carabaos. Surface soil black loam; subsoil contains much fine yellow sand; at 80 centimeters, all sand.
9 A	Subsoil	95.1	.17	.19	.68	.17	.11	.12	8.69	

Soil analyses, district of Pontevedra-La Carlota—Continued.

Soil No.	Nature of soil.	Fine earth.	K_2O.	Na_2O.	CaO.	MgO.	P_2O_5.	N.	Volatile matter.	Remarks.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
10	Surface	95.1	0.15	0.17	0.67	0.15	0.20	0.14	9.89	Hacienda Esperanza. Good soil, said to yield No. 2 sugar. Subsoil red clay and sand.
10 A	Subsoil	94.2	.13	.21	.69	.17	.15	.08	10.00	
11	Surface	94.5	.06	.05	.24	.31	.09	.12	13.61	Hacienda Esperanza. Poor soil, producing only "corriente" sugar. Subsoil at 30 to 35 centimeters is a mixture of clay and yellow sand; below 1 meter, slate-colored sand and gravel.
11 A	Subsoil	93.1	.06	.05	.18	.29	.03	.08	13.18	
12	Surface	93.8	.16	.33	1.08	.32	.20	.15	7.26	Hacienda Najalin. Best land, said to yield about 90 piculs (6.26 metric tons) per hectare of No. 3 sugar. Surface soil from 10 to 20 centimeters deep; subsoil mostly yellow sand; at 30 to 40 centimeters, gravel.
12 A	Subsoil	91.7	.16	.35	1.42	.33	.14	.12	7.90	
13	Surface	93.0	.06	.07	.33	.18	.05	.11	12.39	Hacienda Najalin, higher ground on hillside. Surface soil goes down to about 25 centimeters; below that is red clay to a depth of 5 meters; not as good soil as number 12.
13 A	Subsoil	88.7	.08	.03	.25	.13	.04	.10	11.92	

Soil No.	Nature of soil.	Detritus on 1-mm. screen.	Mechanical analyses of samples (5 grams) of material, district of Pontevedra-La Carlota, passing a 1-millimeter screen. Samples as prepared for chemical analysis.						
		>1 mm., gravel.	1.0–0.5 mm., coarse sand.	0.5–0.25 mm., medium sand.	0.25–0.10 mm., fine sand.	0.10–0.05 mm., very fine sand.	0.05–0.005 mm., silt.	>0.005 mm., clay.	Total.
3	Surface	16.4	3.84	10.64	10.40	12.50	32.96	29.70	100.04
3 A	Subsoil	17.8	3.50	13.36	15.92	12.32	28.48	26.74	100.32
4	Surface	12.3	7.52	15.62	14.60	13.96	34.18	14.52	100.40
4 A	Subsoil	41.8	11.46	25.84	18.08	10.32	25.14	9.52	100.36
6	Surface	4.3	3.38	11.52	12.27	14.83	37.97	19.86	99.83
6 A	Subsoil	9.8	3.68	8.48	11.96	15.02	40.68	20.16	99.98
7	Surface	8.2	2.10	11.61	14.37	13.35	35.09	23.41	99.89
7 A	Subsoil	12.5	4.60	15.04	14.54	9.16	27.24	29.78	100.36
8	Surface	1.9	1.33	6.03	9.31	13.11	43.63	26.31	99.72
8 A	Subsoil	1.1	2.50	3.34	7.90	9.62	45.54	31.44	100.34
9	Surface	3.6	2.18	11.04	17.62	16.22	32.22	20.94	100.22
9 A	Subsoil	4.9	3.00	15.90	19.30	14.20	31.50	16.48	100.38
10	Surface	4.9	2.66	9.86	9.94	12.08	38.46	27.68	100.68
10 A	Subsoil	5.8	2.48	5.76	9.40	12.72	45.64	24.52	100.52
11	Surface	5.5	2.66	7.56	9.82	10.52	27.26	42.32	100.14
11 A	Subsoil	6.9	1.10	4.32	7.20	8.82	31.10	47.64	100.18
12	Surface	6.2	3.18	12.96	19.08	17.30	31.16	16.50	100.18
12 A	Subsoil	8.3	5.78	20.52	18.46	12.54	25.78	16.20	99.28
13	Surface	7.0	1.44	6.48	9.21	11.00	33.63	38.10	99.86
13 A	Subsoil	11.3	0.78	5.96	7.68	8.26	33.20	44.46	100.34

These soils average:

Chemical composition.

Nature of soil.	Fine earth.	K_2O.	Na_2O.	CaO.	MgO.	P_2O_5.	N.	Volatile matter.
	Per cent.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per cent.*
Surface	93.03	0.14	0.20	0.79	0.31	0.17	0.17	10.68
Subsoil	89.60	0.14	0.22	0.88	0.32	0.14	0.11	10.09

Physical composition.

Nature of soil.	>1 mm., gravel.	1.0–0.5 mm., coarse sand.	0.5–0.25 mm., medium sand.	0.25–0.10 mm., find sand.	0.10–0.05 mm., very fine sand.	0.05-0.005 mm., silt.	<0.005 mm., clay.	Total.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Surface	7.0	3.03	10.33	12.66	13.49	34.66	25.93	100.10
Subsoil	12.0	3.89	11.85	13.04	11.30	33.43	26.69	100.21

This seems to be the transition point between the "poor" and the "good" soils of Negros. It is probably the best section of the island where plant cane only is chiefly cultivated, and, analytically considered, would be classed as fairly good sugar land in almost any part of the world. The average composition of these soils is raised somewhat by the inclusion in the table of the four samples from La Granja, which are exceptionally fertile, especially as regards phosphoric acid and nitrogen, and these, possibly, should have been excluded, as, according to the native foreman of the place, who has been there since Spanish times, they have, in former years, received much fertilizer. However, the quantity of fertilizer which is ordinarily used on a field in this country should hardly affect its chemical composition to any serious degree.

The local valuation of soils in this district, quoted under "Remarks," is given for what it is worth. It may be of some value taken in connection with the analyses of canes from the same soils. The standard of what constitutes a "good" soil varies much. In the poorer localities, where all cane produced is, as a rule, rich in sucrose, the best soil is that which yields the largest tonnage of cane; whereas planters from newer, more fertile lands, owing to their absolute dependence on the richness and purity of the cane juice for the quality of their sugar, often consider the best soil to be that which yields cane highest in sucrose, even though the total amount of sugar obtained per hectare be rather small. On no other basis, for instance, could it be understood why an especially rich soil, such as number 2, should be considered "poor".

Numbers 5 to 9, taken from the central portion of the district, represent more fairly the class of land from which the greater majority of all the sugar is produced. Number 6 is a selected sample, taken from what is considered to be the best part of the same field of which number 5 shows the average composition. This portion, chemically, is slightly inferior in every respect, with the exception of the percentage of lime in its subsoil. This may possibly render it more easily cultivable and in a measure account for its apparent superiority. Number 7, a

"poor" soil from the same hacienda as numbers 5 and 6; does not betray marked signs of poverty except in its being much coarser, having a sandier texture, only 77.5 per cent of its subsoil being fine enough to pass a 1-millimeter sieve. Numbers 8 and 9 are two distinct types of soil from the hacienda Carmen, the former, a fairly heavy clay, being considered the better, since the latter, a very sandy loam, though yielding as a rule heavier crops, does not produce as good a quality of sugar. Trusting to chemical analysis alone, number 9 would be considered much superior. The mechanical analyses of these soils show their marked difference, number 8 containing much less sand and more silt and clay than number 9.

In the case of numbers 10 and 12, stated to be "good" soils, as opposed to numbers 11 and 13, "poorer" fields in the same haciendas, analyses agree very nicely with judgment of these lands, based on the practical experience of the planters, numbers 10 and 12 being markedly richer in every element of fertility, and especially so in potash and lime. Physically they contain more very fine sand and silt, and less clay, than numbers 11 and 13.

Following are some analyses of cane grown in this district:

Cane analyses, district of Pontevedra-La Carlota.

No.	Remarks.	Average weight per cane.	In cane.		In juice.			
			Sucrose.	Fiber.	Brix.	Sucrose.	Quotient of purity.	Reducing sugar.
		Kilos.	*Per ct.*	*Per ct.*		*Per ct.*		*Per ct.*
1	Selected at random from the mill, hacienda Carmen Chica; said to be of average size for this estate and to yield No. 2 sugar	1.23	14.43	9.71	18.00	16.47	91.47	0.56
6	Plant cane, eleven and one-half months old, grown in the experimental plot of the Bureau of Agriculture Experiment Station at La Granja. Soil number 4	1.46	10.80	9.08	16.16	12.27	75.93	2.26
10	Soil number 5	1.13	13.66	8.57	17.31	15.31	88.53	1.10
12	Soil number 6; yields No. 1 sugar	0.85	16.72	10.36	20.40	18.88	92.53	0.51
13	Plant cane from a field considered to be poor soil, hacienda Carmen Chica. Soil number 7; said to yield No. 3 sugar	1.20	16.12	9.45	19.55	18.24	93.28	0.50
14	Plant cane from good soil, number 8; said to yield No. 1 sugar. Hacienda Carmen	1.18	16.17	10.84	20.05	18.42	91.85	0.60
15	Plant cane from soil number 9, hacienda Carmen, a field fertilized with manure two years previously; said to yield No. 3 sugar	0.93	13.04	8.95	16.76	14.51	86.56	0.89
16	Plant cane, twelve months old, from soil number 10, hacienda Esperanza; said to yield No. 2 sugar	1.22	11.65	8.13	15.77	12.76	80.87	1.45
17	Plant cane, fourteen months old, from soil number 11, hacienda Esperanza. Soil considered very poor for cane, as it yields only "corriente" sugar	0.96	14.22	9.74	17.99	15.97	88.78	1.09
18	Plant cane, twelve months old, from soil number 12, hacienda Najalin. Said to yield No. 3 sugar, which is considered good for this vicinity	1.16	13.57	8.05	17.61	15.14	87.96	1.26
19	Plant cane, fifteen months old, from soil number 13, hacienda Najalin. This field is now being cut and is yielding "húmedo" sugar	1.18	13.74	9.39	17.38	15.66	90.12	0.62
	Average	1.14	14.01	9.30	17.91	15.79	87.99	0.99

These canes average lower in sucrose and purity, but are at the same time decidedly larger than those examined in any other district. The high glucose and low fiber of some of them might lead to the belief that they had been cut too soon, but such could hardly have been the case, as they were practically all at least twelve months old, and, as a rule, were taken from fields which were at the time being cut for grinding. Without doubt the time of year had some influence in this respect, however, as La Carlota was the first district visited, and the above analyses were made during the months of January and February, rather early in the grinding season, the average throughout the year would probably result a little better. Nos. 6, 18, and 19 are more typical of the higher lands, while the other samples represent the central and lower portion of the district.

Number 6, taken from a small experimental plot at La Granja, was analyzed more for purpose of comparison with other varieties of cane growing in the same field than as illustrating results ordinarily obtained here. These other varieties of cane will be discussed in a separate paragraph. Numbers 10 and 12 are from the soils numbered 5 and 6, respectively, and, coming as they do from the same field, certainly indicate a marked difference due to variation in the quality of the soil; number 12, from the so-called "best" portion of the field, in reality being much better from the standpoint of the local sugar boiler, as its juice is decidedly purer and richer in sucrose, but, taking into consideration the increased weight of number 10, there is really very little choice between the two in point of available sugar.

Numbers 14 and 15 illustrate the difference in quality of cane grown in clay and in a sandy soil, it being the consensus of opinion among planters in general that under normal conditions the former produces cane of superior quality, but rather small in size, while that yielded by the latter is inclined to be poorer in sucrose, although if given an abundant supply of water it often attains a luxuriant growth. In this particular instance the cane from the sandy soil is not only poorer in sucrose, but is smaller as well, the latter feature being an exception to the general rule.

In numbers 16 and 17 we have another instance of a rich soil producing a larger cane, but one comparatively low in sucrose and purity, while a neighboring field of much less fertility yields a richer, although smaller, crop. The physical difference in the soils from which these canes were taken, as stated above, undoubtedly does its share toward changing the composition of the cane.

In numbers 17 and 18, practically no difference can be detected between cane grown in a rich and in a decidedly poorer soil.

BINALBAGAN-ISABELA.

Theoretically, this is contiguous to the Pontevedra district, and may be reached from there by a trail passing over the foothills and south through La Castellana, from which place the town of Isabela is distant in an air line only about 12 kilometers. Practically, owing to poor roads and lack of transportation facilities, considerable time and expense is saved by returning to Iloilo for a fresh start, and from there proceeding by lorcha directly to the town of Binalbagan, the sail down from Iloilo requiring from eight to twelve hours, during the northeast

monsoon. The return trip, against the wind, may take anywhere from twenty-four hours to a week. The town of Binalbagan is situated near the mouth of a river of the same name, 25 kilometers directly south of Pontevedra. Owing to the shallowness of this river, the lorcha landings are all located within a short distance of its mouth, and all sugar from the district must be brought to this point for shipment to Iloilo, either in bull carts or down the river in small barges of a few tons' capacity. The best sugar lands lie at a distance of from one-half to 2 kilometers on either side of the Binalbagan River, extending thus for 20 kilometers inland to the town of Isabela, up to which place the soil presents the usual characteristics of alluvial ground in Negros, being quite sandy near the river bank, but within a kilometer or so resolving itself into a more or less heavy, wet clay, which, because of lack of drainage, is given over chiefly to the cultivation of rice. From Isabela the cane fields spread out north and south for 5 or 6 kilometers, and to an equal distance back into the mountains, but here they are more broken up by hills and more varied in their character. The same conditions concerning transportation in this district prevail as in the majority of other parts of the island: "In dry weather, all roads are good; when it rains, one stays at home."

Area and production of the Binalbagan-Isabela district (1908).

	Amount.	
Number of growers, 43:	*Hectares.*	*Per cent.*
Area of growers' land planted in sugar cane	2,957	40.4
Area of growers' land suited to cane culture but not planted	2,868	39.1
Other land suited to cane culture but not planted	1,500	20.5
Total sugar land	7,325	
Average amount of sugar land in hectares owned by each grower:		
Planted	68.8	
Unplanted	66.7	
Total	135.5	
	Piculs.	*Metric tons.*
Average amount of sugar produced by each grower	2,472	156.4
Average amount of sugar produced per hectare planted	36.0	2.27
Total sugar produced	106,308	6,724

Although this is one of the richest localities in Negros, it will be noted that the production per hectare is one of the lowest, due largely to the fact that practically all the lands here allow of the growing of ratoon canes, which system, because of the saving in expense, as it is not necessary to replant, is often carried to an extreme, resulting in very poor crops. From 15 to 30 per cent only of all the sugar produced in this region is from plant cane. The average yield for the whole district is also much reduced by the inclusion of the lower or

Binalbagan portion. Nearly all the land here is owned by one large estate, which, apparently lacking the necessary capital properly to cultivate it, either allows it to lie idle or in uncultivated ratoons of long standing, or rents it out in small parcels to native planters. The average yield of land actually in cane in the municipality of Binalbagan is only 1.35 metric tons per hectare, whereas the somewhat better cultivated, but no richer, soils of Isabela produce a little over double this amount. The average amount of land owned by each planter is just about the same as that in other parts of the island, although decidedly more is reported as under cultivation, this latter circumstance being also due to the greater preponderance of ratoon cane in this region.

Below are given analyses of soils throughout this district. As no cane analyses were made here, the figures as to quality and quantity of sugar produced, etc., refer to statements made by individual planters.

Soil analyses, district of Binalbagan-Isabela.

Soil No.	Nature of soil.	Fine earth.	K_2O.	Na_2O.	CaO.	MgO.	P_2O_5.	N.	Volatile matter.	Remarks.
		Per ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	
38	Surface	100.0	0.15	0.16	1.38	1.04	0.23	0.13	9.87	Hacienda San Jose. "Tierra mestiza" along bank of Binalbagan River. Land close to river is considered best, as farther away it is too low and better suited for rice than cane. This soil covered by floods each year; *said* to yield up to 200 piculs (12.65 metric tons) Nos. 1 and 2 sugar per hectare. Surface soil light loam; subsoil at 30 centimeters, black clay mixed with yellow sand, growing somewhat sandier with increase in depth.
38 A	Subsoil	99.9	.13	.14	1.37	.91	.19	.10	9.40	
39	Surface	99.9	.15	.13	1.57	.75	.24	.13	9.47	Hacienda Santa Irene, Binalbagan. Field about 500 meters from rivers, clay loam. Manager of plantation has no idea of amount of sugar produced. Subsoil, at 25 centimeters, black clay mixed with fine yellow sand.
39 A	Subsoil	100.0	.13	.10	1.20	.90	.21	.10	10.00	
40	Surface	98.5	.18	.24	1.67	1.09	.18	.06	5.65	Hacienda San Jose, Caman Caman, Isabela. Sandy loam, near a small river back toward the mountains; said to give large yield of cane, but poor quality. Subsoil at about 15 centimeters, nearly all sand down to 80 centimeters, where some black clay is touched.
40 A	Subsoil	99.0	.15	.28	1.70	1.00	.15	.03	5.68	
41	Surface	99.9	.16	.13	.93	.90	.20	.13	8.54	Hacienda San Jose, Caman Caman, Isabela. Land a little farther from river; not so sandy as number 40; yields No. 1 sugar, but not so much as number 40. Subsoil at 30 centimeters, black clay mixed with some sand.
41 A	Subsoil	99.8	.15	.11	.90	.72	.14	.09	9.24	

Soil analyses, district of Binalbayan-Isabela—Continued.

Soil No.	Nature of soil.	Fine earth.	K_2O.	Na_2O.	CaO.	MgO.	P_2O_5.	N.	Volatile matter.	Remarks.
		Per ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	
42	Surface	99.7	0.11	0.05	0.72	0.18	0.08	0.10	8.80	Hacienda Constancia, Isabela. "Tierra mestiza." Considered a very good soil for plant cane, but not for ratoons; 20 hectares have averaged 145 piculs (9.18 metric tons) sugar per hectare from plant cane. Can produce two years of ratoons, but not more. Subsoil at 25 centimeters, black clay and some sand, becoming sandier as deeper; at 50 centimeters, a little gravel and white clay.
42 A	Subsoil	99.3	.14	.04	.70	.77	.08	.09	9.67	
43	Surface	100.0	.21	.37	2.23	.74	.25	.17	9.39	Hacienda Nalipay, Isabela. Black loam, not reached by floods; said to yield 100 piculs (6.33 metric tons) sugar per hectare of plant cane; produces four to five ratoon crops. Subsoil, practically no difference from surface at least down to 80 centimeters; sample "subsoil" was taken from 60 to 80 centimeters.
43 A	Subsoil	100.0	.15	.28	1.97	.94	.23	.14	10.91	
44	Surface	100.0	.10	.23	1.67	.91	.16	.15	11.82	Hacienda Nalipay. "Tierra baja" black clay; said to be good for plant canes, but only yields about two years of ratoons. Subsoil, black clay at 20 centimeters, getting stiffer and wetter with increased depth; at 80 centimeters, still black clay.
44 A	Subsoil	100.0	.09	.14	1.61	.89	.22	.10	11.92	
45	Surface	99.8	.10	.24	2.05	.95	.16	.13	11.59	Hacienda Antolanga, Isabela. Black clay, considered the poorest land in the estate. Subsoil at 25 centimeters, stiff black clay. This hacienda is one of the farthest back toward the mountains of the Isabela district.
45 A	Subsoil	99.9	.08	.23	2.25	1.06	.07	.08	9.94	
47	Surface	99.8	.21	.17	1.34	.82	.26	.17	10.40	Hacienda Progreso, Isabela. Black loam, 200 meters from river. Subsoil begins about 35 centimeters; clay and some sand.
47 A	Subsoil	99.8	.18	.11	1.25	.94	.14	.13	11.01	
48	Surface	99.9	.11	.07	1.23	.86	.22	.16	12.07	Hacienda Tagum Tagum, Isabela. Clay loam washed by yearly floods; called poor land; will yield 100 piculs (6.33 metric tons) of No. 1 sugar per hectare from plant cane if allowed to rest a year, but only 50 to 60 piculs (about 3.5 metric tons) from first ratoon; after that does not yield more unless allowed to rest again. Subsoil at 25 to 30 centimeters, stiff black clay.
48 A	Subsoil	99.7	.11	.06	1.33	.92	.09	.09	10.87	

Soil analyses, district of Binalbayan-Isabela—Continued.

Soil No.	Nature of soil.	Fine earth	K_2O.	Na_2O.	CaO.	MgO.	P_2O_5.	N.	Volatile matter.	Remarks.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
49	Surface	99.9	0.14	0.16	1.72	0.82	0.22	0.21	12.51	Hacienda Tagum Tagum; higher land near river. A lighter loam, more easily worked. Yields 125 piculs (7.9 metric tons) sugar per hectare from plant cane and 80 piculs (5.5 metric tons) from first ratoons. Land will produce from four to five ratoon crops. Subsoil at 50 to 60 centimeters, very little different from surface.
49 A	Subsoil	99.8	.10	.06	1.62	.99	.12	.11	12.49	

Soil No.	Nature of soil.	Detritus on 1-mm. screen.	Mechanical analyses of samples (5 grams) of material, district of Isabela, passing a 1-mm. screen. Samples as prepared for chemical analysis.						
		1 mm., >gravel.	1.0–0.5 mm., coarse sand.	0.5–0.25 mm., medium sand.	0.25–0.10 mm., fine sand.	0.10–0.05 mm., very fine sand.	0.05–0.005 mm., silt.	<0.005 mm., clay.	Total.
38	Surface	0.0	0.06	0.74	9.10	14.38	56.50	19.08	99.86
38 A	Subsoil	0.1	0.02	0.76	9.84	23.42	51.06	14.92	100.02
42	Surface	0.3	1.22	7.36	14.38	14.90	39.52	22.60	99.98
42 A	Subsoil	0.7	3.86	11.90	13.64	12.64	31.12	26.76	99.92
45	Surface	0.2	0.14	0.72	10.80	21.68	45.88	20.24	99.46
45 A	Subsoil	0.1	0.22	0.54	6.62	20.60	47.74	23.54	99.26
49	Surface	0.1	0.14	3.90	9.98	12.50	53.06	20.10	99.68
49 A	Subsoil	0.2	0.08	1.10	11.68	23.08	45.70	18.16	99.80

The average soil from this district is as follows:

Chemical composition.

Kind of soil.	Fine earth.	K_2O.	Na_2O.	CaO.	MgO.	P_2O_5.	N.	Volatile matter.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Surface	99.76	0.15	0.18	0.50	0.88	0.20	0.14	10.01
Subsoil	99.76	0.13	0.14	1.45	0.91	0.15	0.10	10.10

Physical composition.

Nature of soil.	>1 mm., gravel.	1.0–0.5 mm., coarse sand.	0.5–0.25 mm., medium sand.	0.25–0.10 mm., fine sand.	0.10–0.05 mm., very fine sand.	0.05–0.005 mm., silt.	<0.005 mm., clay.	Total.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Surface	0.2	0.39	3.18	11.07	15.87	48.74	20.51	99.75
Subsoil	0.3	1.05	3.58	10.45	19.94	43.91	20.85	99.75

At first glance, this appears but very little better than the average soil in the neighboring district of Pontevedra-La Carlota, and one is somewhat at a loss to explain why so much more ratoon cane is grown here, but, leaving out of account the fresher, less-cultivated hill soils of the latter, where, indeed, much ratooning is done, the Binalbagan-Isabela district will be found uniformly decidedly richer in composition. Many of the fields along the Binalbagan River are overflowed during each rainy season, and thus have their fertility renewed by deposits of silt and clay brought down from the mountains. The relatively larger amount of lime in these soils very probably is an additional factor tending toward increased fertility. It is a curious fact, to be noted generally throughout the Island of Negros, that the better a soil the more lime, as a rule, it will be found to contain, and even in those sections which are, on the whole, excessively well supplied with this element, fields which have the reputation of producing exceptionally good crops of cane are often found to run higher in lime than their poorer neighbors. It is very difficult to draw conclusions of any kind as to the respective value of soils merely from growers' estimates of their yield, many of these being purely impromptu guesswork, since cane is never weighed in the Philippines and most fields are measured by the number of "tops" planted in them; nevertheless, the relative merits of different fields in his own hacienda should be fairly well known by each planter, and any consistent analytic differences between so-called "good" and "poor" soils are at least worthy of note. Of all the soils examined in this district, none may really be termed "poor" in the same sense as some of the "exhausted" soils of Silay and Bago. All of them are perfectly capable of producing good crops of cane when properly cultivated, although some show a greater capacity for ratooning than ohers. Theoretically, and this is borne out in Negros at least by practical experience, a soil to produce good ratoon crops must either contain a relatively larger amount of plant food than one which is fit for plant cane only, or, by some means—be it physical, mechanical, or biological—must be enabled more readily to supply the young sprout with its necessary nourishment; since, when cane is planted new every year, the soil is first thoroughly mixed and broken up by plowing and harrowing, while the ratoon must depend for its growth largely upon that portion of the soil directly around it and untouched by cultural operations. All other conditions being equal, it would seem quite possible that a field yielding heavy crops if planted afresh each year, might be quite unprofitable for ratoons through lack of sufficient excess of any one constituent, while another piece of land in the same locality might produce rather less sugar from the first planting, and yet continue ratooning for many years with only slightly diminished yields.

Such may be the case with the four soils, numbers 42, 44, 45, and 48, which are called "poor," since they do yield many ratoon crops. Analysis shows them to be just about as rich as any of the other soils of the district in every element except potash, in which latter they are uniformly lower, the figures ranging in the surface soils from 0.10 to 0.11 per cent. It will be remembered that in Bago and Silay, whose lands average 0.11 per cent of potash or less, ratoons are very uncommon, and one might be almost justified in making the statement that, under the conditions prevailing in Negros at the present time, a soil which contains less than 0.11 per cent of potash will in all probability not yield profitable ratoon crops, even though it be in other respects very fertile. The converse of this is by no means to be inferred, as a dozen other factors might be just as important or more so than the amount of potash, or, for that matter, of any other element which it contains. Still, it would be interesting to try the effect of a potash fertilizer on some of the non-ratooning soils of this district.

ILOG-CABANCALAN.

The last of the large sugar districts in Occidental Negros lies 20 kilometers south of Binalbagan in the Ilog River valley, and consists of a strip of land about 7 kilometers wide and 25 kilometers long. Transportation between this district and Iloilo is carried on in the same way and requires about the same length of time as from Binalbagan. Freight on sugar to Iloilo is from 20 to 25 centavos per picul (3.16 to 3.95 pesos per metric ton). The Ilog River is navigable by sugar lorchas at high tide as far inland as the hacienda San Isidro, about the center of the district, but, owing to a sand bar at the mouth of the river and shallow places farther up, at least two high tides must be awaited in order to get a boat in or out from this place. It takes about one hour to come down the river in a banca from the town of Cabancalan to the hacienda San Isidro; from there on to the town of Ilog an hour and a half longer; and thence to the mouth of the river from one to two hours, according to the tide. A low mountain range, distant from 5 to 10 kilometers, lies on the right bank, going up. The sugar lands along the left bank are best within 2 or 3 kilometers of the river, then deteriorate into low rice lands for a short distance, and finally merge into the rough, stony country between this point and Jimamaylan. A fairly good wagon road exists on this side between the towns of Ilog and Cabancalan, and a passable trail northward to Suay, Jimamaylan, and Binalbacan. The roads on the right side of the river are limited to those kept up by the individual haciendas.

The sugar lands of this district have been formed by alluvial deposits from the river, which overflows annually, flooding a large proportion of the cane fields, but doing, as a rule, little damage to the growing cane. They are classified locally according to their physical make-up into three main types of soil. "Bombon," a light, very sandy soil, found in high places close along the river banks, is made up of the fine sand and other heavier sediment which first settles as the river overflows its boundaries. It has only a comparatively shallow

covering of vegetable surface soil with a subsoil of extremely fine yellow sand and silt. Cane planted here grows superlatively well in years of plentiful rainfall, but is apt to yield a rather watery, impure juice, and does not stand drought well. With a little irrigation to tide them over dry spells, such lands should produce much better than they do at present.

Adjoining the "bombon" soil and at a somewhat lower level and a few hundred meters from the river is the so-called "tierra mestiza," a black loam, which, as its name indicates, is a "mixture" of very fine sand and silt, with a little clay. The subsoil is likewise very fine sand, silt, and black clay, sometimes well mixed, sometimes in streaks. This is considered the best land for cane growing, as it produces large cane of good quality, has good natural drainage, and yet is not injured by a moderate amount of dry weather.

Farther away, in lower land, where the floods stand at times long enough to deposit the finest silt and clay which they carry, are the "bankil" or heavy clay soils,[5] which are stated to yield the richest cane, although not as heavy in tonnage as the others. In dry years these lands are reliable producers, but early, excessive rains coming before the young cane has attained a sufficient height often have a very harmful effect, unless the land is divided into small fields by ditches and artificially drained at considerable expense. The heaviest of these "bankil" soils are not much used at present for cane growing because of the difficulty of working them, and are either left uncultivated or used as rice lands.

Area and production of the Ilog-Cabancalan district (1908).

	Amount.	
Number of growers, 22.	*Hectares.*	*Per cent.*
Area of growers' land planted in sugar cane	1,632	46.8
Area of growers' land suited to cane culture but not planted	857	24.6
Other land suited to cane culture but not planted	1,000	28.6
Total sugar land	3,489	
Average amount of sugar land in hectares owned by each grower:		
Planted	74.2	
Unplanted	38.9	
Total	113.1	
	Piculs.	*Metric tons.*
Average amount of sugar produced by each grower	5,218	330.0
Average amount of sugar produced per hectare planted	70.3	4.45
Total sugar produced	114,804	7,261

[5] Number 32 is a typical "bankil" soil. Compare its mechanical analysis with those of other soils from this district.

Compared with other districts, the Ilog River valley produces much more sugar per hectare of land planted, although three-fourths of this comes from ratoon cane, and the limit of production has by no means been approached. Somewhat less than the average amount of land is here owned by each planter, but he has a much larger proportion of what he owns under cultivation and produces annually over twice as much sugar as the average grower throughout the island. Apparently, only a small percentage of the total land fit for sugar production in this district is unused, but in reality about twice as much as is now considered suitable for cane growing could, by means of an efficient system of subsoil drainage for the heavy "bankil" soils and rice lands, be brought into use.

The following are analyses of typical soils from this locality.

Soil analyses, district of Ilog-Cabancalan.

Soil No.	Nature of soil.	Fine earth.	K_2O.	Na_2O.	CaO.	MgO.	P_2O_5.	N.	Volatile matter.	Remarks.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
29	Surface	99.7	0.21	0.24	2.05	1.15	0.18	0.10	8.32	Hacienda San Isidro. "Tierra mestiza," a mixture of black clay and sandy loam; considered best kind of soil; said to average 150 piculs (9.50 metric tons) of Nos. 2 and 3 sugar per hectare from plant cane; now in first ratoon. This land produces best with considerable rainfall; does not stand drought well. Subsoil much the same as surface, but becomes somewhat sandier as goes deeper; at 80 centimeters, still much clay; below this said to be all fine sand.
29 A	Subsoil	100.0	.19	.22	1.96	1.15	.16	.09	8.14	
30	Surface	99.7	.19	.24	4.66	1.31	.17	.09	8.04	Hacienda San Isidro. Same field as number 29, but closer to the Ilog River and soil much sandier ("tierra bombon"). Yields larger with plant cane, but much cane dies if season is dry; will not yield more than three years of ratoons unless much water; now in first ratoon. Subsoil begins at from 30 to 50 centimeters, nearly all fine yellow sand.
30 A	Subsoil	100.0	.17	.30	4.43	1.32	.21	.07	7.20	
31	Surface	99.9	.24	.18	4.40	1.33	.20	.15	9.04	Hacienda Maria. "Tierra mestiza," a mixture of "bankil" and "bombon." Best land said to yield 120 piculs (7.6 metric tons) sugar per hectare. Surface soil is a clay loam; subsoil beginning at 25 to 30 centimeters, a very sandy loam, nearly pure sand in parts, down to 50 to 60 centimeters, where a layer of clay is again encountered. This soil is flooded by the Ilog River nearly every year.
31 A	Subsoil	99.9	.20	.21	4.28	1.39	.19	.13	8.42	

Soil analysis, district of Ilog-Cabamalan—Continued.

Soil No.	Nature of soil.	Fine earth.	K_2O.	Na_2O.	CaO.	MgO.	P_2O_5.	N.	Volatile matter.	Remarks.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
32	Surface	99.7	0.20	0.23	3.00	1.43	0.16	0.18	11.21	Hacienda Soledad. "Tierra bankil" or stiff black clay. Subsoil about 30 centimeters, black clay mixed with some sand, becoming sandier as deeper; at 45 centimeters, much sand.
32 A	Subsoil	98.4	.17	.29	1.84	1.01	.09	.06	6.15	
33	Surface	99.9	.23	.19	2.02	1.50	.24	.12	8.10	Hacienda San Juan. "Tierra mestiza," said to be very good land, but poorly cultivated owing to lack of labor; said to yield about 70 piculs (4.43 metric tons) of No. 2 sugar per hectare; now in plant cane. Subsoil almost same as surface down to about 40 centimeters; below this a very little sand mixed with much clay.
33 A	Subsoil	99.8	.23	.18	2.05	1.42	.19	.09	7.92	
34	Surface	99.9	.20	.22	4.52	1.32	.17	.13	8.82	Hacienda San Juan. Best land; a rather light loam, but not sandy, now in third ratoon; said to yield 100 piculs (6.33 metric tons) or more of No. 3 sugar per hectare. Subsoil from 25 to 30 centimeters down, considerable yellow sand.
34 A	Subsoil	99.8	.19	.22	5.46	1.09	.15	.07	6.80	
35	Surface	100.0	.19	.14	4.90	1.64	.22	.18	10.75	Hacienda San Luis. Clay loam, about 200 meters from river. Is flooded every year; now growing fourth ratoon crop. Subsoil much the same as surface, but somewhat stiffer clay.
35 A	Subsoil	99.9	.18	.12	4.22	1.89	.17	.13	10.10	
36	Surface	99.9	.20	.15	3.19	1.06	.17	.13	8.14	Hacienda San Lucas. "Tierra bombon," a sandy loam not reached by floods; said to yield 120 piculs sugar (7.60 metric tons) per hectare from plant cane and 90 piculs (5.70 metric tons) from first ratoons. Subsoil at 25 centimeters, mixture of loam and very fine sand; at 40 centimeters, nearly all sand; at 80 centimeters, still pure fine sand, no gravel.
36 A	Subsoil	99.9	.16	.18	3.49	1.17	.15	.06	6.56	
37	Surface	96.9	.25	.17	2.85	1.32	.23	.13	7.80	Hacienda San Isidro. Best field, "tierra mestiza;" most of field is covered by yearly floods from river. Last year this field (7 hectares) said to have averaged 200 piculs (12.65 metric tons) per hectare of No. 3 sugar from canes planted in October and cut in January (fifteen months old). Soil is a black loam; subsoil at 30 centimeters, black clay mixed with very fine sand or silt in streaks; at 60 centimeters, mostly black clay.
37 A	Subsoil	98.0	.19	.19	2.47	1.30	.21	.11	7.70	

Soil No.	Nature of soil.	Detritus on 1-mm. screen.	Mechanical analyses of samples (5 grams) of material, district of Ilog-Cabancalan, passing a 1-mm. screen. Samples as prepared for chemical analysis.						
		1 mm., gravel.	>1.0-0.5 mm., coarse sand.	0.5-0.25 mm., medium sand.	0.25-0.10 mm., fine sand.	0.10-0.05 mm., very fine sand.	0.05-0.005 mm., silt.	<0.005 mm., clay.	Total.
29	Surface	0.3	0.08	1.28	9.96	32.70	44.64	11.42	100.08
29	Subsoil	0.0	0.00	0.26	7.88	31.48	50.48	9.08	99.14
30	Surface	0.3	0.12	1.14	12.78	45.74	33.28	7.12	100.18
30	Subsoil	0.0	0.02	0.80	17.16	35.06	40.18	6.60	99.82
32	Surface	0.3	0.44	3.36	14.76	10.28	46.22	25.48	100.54
32	Subsoil	1.6	0.94	7.70	17.28	9.62	37.60	26.80	99.94
33	Surface	0.1	0.06	0.42	9.90	39.40	38.02	12.84	100.64
33	Subsoil	0.2	0.04	0.20	7.04	32.72	49.96	10.06	100.02
34	Surface	0.1	0.08	2.62	16.80	34.72	38.34	7.70	100.26
34	Subsoil	0.2	0.40	9.00	26.54	21.18	32.78	9.92	99.82
35	Surface	0.0	0.06	0.98	12.22	15.42	52.02	19.24	99.94
35	Subsoil	0.1	0.02	0.38	13.70	12.80	51.82	20.40	99.12
36	Surface	0.1	0.08	1.44	16.44	28.44	43.38	10.14	99.92
36	Subsoil	0.1	0.04	1.74	27.12	30.32	33.72	7.52	100.46

The average of these surfaces and subsoils is as follows:

Chemical composition.

Nature of soil.	Fine earth.	K_2O.	Na_2O.	CaO.	Mgo.	P_2O_5.	N.	Volatile matter.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Surface	99.51	0.21	0.20	3.51	1.34	0.19	0.13	8.91
Subsoil	99.52	0.19	0.21	3.36	1.31	0.17	0.09	7.67

Physical composition.

Nature of soil.	>1 mm., gravel.	1.0-0.5 mm., coarse sand.	0.5-0.25 mm., medium sand.	0.25-0.10 mm., fine sand	0.10-0.05 very fine sand.	0.05-0.005 mm., silt.	<0.005 mm., clay.	Total.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Surface	0.2	0.13	1.61	13.27	29.53	42.27	13.42	100.22
Subsoil	0.3	0.21	2.87	16.67	24.74	42.36	12.91	99.76

The practically uniform composition, chemically, of these soils all along the river valley is probably due to their original formation from the same source—sand, silt, and clay brought down from the mountains by the summer floods. In comparison with the districts thus far examined they are much richer in most of the so-called elements of fertility, being exceptionally so in lime, of which substance a very much

larger percentage is here found than in soils from any other part of Negros. Much of this exists as the carbonate, as is shown by the marked effervescence which takes place on treating almost any of the Ilog soils with acid. Nitrogen, only, appears to be a trifle low, especially in some of the sandy, "bombon" lands, but this is rather to be expected in soils having the physical make-up of these under consideration. It is evident that, as all the land here contains an excess of plant food sufficient for both plant canes and ratoons, without considering the additional nutrient matter supplied each year by the overflowing of the river, differences in productivity and in quality of the cane for the greater part be due to the amount of care taken in cultivation, together with the combined effects of the weather and the physical composition of the soil. According to the quantity of rainfall in a given year, a sandy soil may produce much more cane than a heavy clay, or the reverse, so that only by means of experiments covering many years, together with meteorologic observations during the same period, would it be possible to state which type of soil was really best suited to cane in this vicinity. However, a few cane analyses were made here and are given in the following table:

Cane analyses, district of Ilog-Cabancalan.

No.	Remarks.	Average weight per cane.	In cane. Sucrose.	In cane. Fiber.	In juice. Brix.	In juice. Sucrose.	In juice. Quotient of purity.	In juice. Reducing sugar.
		Kilos.	*Per ct.*	*Per ct.*		*Per ct.*		*Per ct.*
32	First ratoon cane from soil number 29, hacienda San Isidro. Canes twelve months old	0.98	18.37	10.10	22.33	20.98	93.96	0.23
33	First ratoon cane from soil number 30, hacienda San Isidro. Soil is sandier and nearer river than that in which canes number 32 are growing. Canes 12 months old have fallen down worse than number 32	1.00	15.58	9.35	20.28	17.81	87.84	1.00
34	Plant cane, fourteen to fifteen months old, from soil number 32; a black clay. Hacienda Soledad. Canes slender but fairly long	0.88	15.87	11.14	20.61	18.66	90.53	0.49
35	Plant cane thirteen months old, from soil number 33, hacienda San Juan. These canes small and stunted in growth on account of lack of cultivation; were attacked by locusts while young	0.41	17.73	10.02	21.39	20.33	95.06	0.12
36	Third ratoon cane from soil number 34, hacienda San Juan	0.89	15.29	9.72	19.43	17.52	90.14	0.62
37	Hacienda San Luis	0.63	17.46	9.23	22.03	18.96	90.14	0.82
38	First ratoon cane, eleven months old, from soil number 36, hacienda San Lucas; said to yield about 90 piculs (5.7 metric tons) per hectare	0.71	18.34	9.15	22.17	20.85	94.06	0.18
	Average	0.79	16.95	9.81	21.18	19.30	91.67	0.49

Taken collectively, the cane from Ilog is quite similar in composition to that of Bago, a condition hardly to be expected in view of the marked dissimilarity between the soils of the two districts and the fact that the majority of the canes examined in Ilog were ratoons while those from Bago were all from the first planting. Probably these are compensating differences, since both a poor soil and the growing of ratoon crops have an apparent tendency to produce a cane rather smaller and richer than the ordinary. In the case of Ilog, also, the analyses were made during the month of April, at the latter end of the grinding season, after several weeks of dry, hot weather, when all the cane would naturally be somewhat drier and richer than usual, so that in all probability an average of the crop throughout the year in this district would be considerably larger and somewhat poorer in sucrose than the figures quoted. Few of the individual canes in this list vary sufficiently from the average to indicate any distinctions due to the soil in which they are growing.

Numbers 32 and 33 again illustrate the difference often noted between a loam or clay and a sandy soil, although the two fields from which they were taken are adjoining ones and their soils chemically much the same. Number 33, although by no means a poor cane, is still decidedly lower in sucrose and fiber than number 32, the one from the heavier soil,[6] while its higher reducing sugar content, 1 per cent, would almost indicate that it was hardly ripe, yet both fields were of the same age. The higher fiber of number 34 was probably brought about by the long time it had remained in the ground, becoming thoroughly mature and dry. Number 35 shows the damage done by locusts in stunting the growth of a cane field, even when they do not entirely destroy it. Number 36, from a light loam with sandy subsoil, is characteristically lower in sucrose, while number 38, from a very similar soil, not only does not show this distinction, but is considerably purer and richer in sucrose than the average.

SAN CARLOS.

The larger of the two important sugar centers on the east coast is situated in the northern part of Negros, directly across the island from La Carlota, on the arbitrary dividing line separating Occidental and Oriental Negros. The town of San Carlos, about the center of this district, possesses a safe, although not very deep, harbor, formed by a projecting point of land and a slight indentation in the coast, at which point a small wharf or lorcha landing has been built. Protected by its own coast line from the northeast monsoon, the harbor is quite calm during the grinding season, and is sheltered from the southwest winds of the rainy season by the small island of Refugio, lying

[6] According to mechanical analysis, neither of these soils contain a large amount of clay, but the one producing cane, number 32, is decidedly finer in texture than its neighbor.

close by, so that very little trouble is here experienced from rough weather. A channel between Refugio and the mainland is sufficiently deep for vessels of moderate size, which may anchor within a short distance of the wharf. A fairly regular mail and passenger service to Iloilo, 180 kilometers distant by sea, is available once or twice a week, the trip requiring about fourteen hours, while sugar and heavy freight is transported, as in other districts, by lorchas, which are usually towed up against the wind for about half the distance, or until well around the northern end of the island, and then cast loose to sail down with the wind into Iloilo. The customary freight rate here is 25 centavos per picul (3.95 pesos per metric ton).

The sugar plantations of San Carlos lie in a direct line along the coast, extending from the hacienda Santo Tomas in the north to Valle Hermoso in the south, a distance by land of 23 kilometers, by sea a trifle less, and are connected by wagon roads passable in dry weather down as far as the haciendas Santa Cruz and Santo Niño (Mabuni), 5 kilometers south of the town. In passing the next 3 kilometers between Santo Niño and the hacienda Fortuna, the land becomes much more broken and accidental in character, and from this point on to Valle Hermoso there exists only a rocky trail along the coast, from one and one-half to two hours being required to traverse the 5 kilometers between these two places on horseback.

The sugar lands of this side, unlike those of western Negros, do not extend inland to any distance, but are shut off by mountains which are never more than 3 or 4 kilometers from the sea, and thus afford room for only one fairly large estate between the foothills and the coast. All the haciendas of this district, with the exception of Fortuna and Valle Hermoso, the two farthest south, occupy the fairly level strip of land which has the town of San Carlos as its approximate center. These two haciendas, of much larger extent than the others, are made up of a number of separate fields, wherever level ground can be utilized in the valleys between the hills.

No less than eight small streams pass through the district, but none of them are large enough for navigation of any kind, so that the sugar lorchas must anchor close to the coast and have their freight brought out to them in small boats, or, in the town of San Carlos and in the hacienda Fortuna, be loaded directly from small, private wharves.

Area and production of the San Carlos district (1908).

	Amount.	
Number of growers, 14.	*Hectares.*	*Per cent.*
Area of growers' land planted in sugar cane	2,080	60.4
Area of growers' land suited to cane culture but not planted	866	25.1
Other land suited to cane culture but not planted	500	14.5
Total sugar land	3,446	
Average amount of sugar land in hectares owned by each grower:		
Planted	148.6	
Unplanted	61.9	
Total	210.5	
	Piculs.	*Metric tons.*
Average amount of sugar produced by each grower	5,450	344.7
Average amount of sugar produced per hectare planted	36.7	2.32
Total sugar produced	76,300	4,826

The average grower of this district owns a larger amount of land, has more of it under cultivation, and produces annually a greater quantity of sugar than elsewhere in Negros, although the average yield of sugar per hectare reported under cultivation is very small, being, in fact, less than half of what even a moderately good field in this locality will ordinarily produce. San Carlos has suffered much of late from drought, due in a great measure to the almost total destruction of the forests and shrubbery in the foothills and mountains lying just back of all the plantations. This has been brought about by nomadic mountain people, who burn off a small patch of land to form a "caingin," which they plant in corn for a year or so, until weeds begin to spring up and a little real work is necessary for further cultivation, when they move on to devastate more forest land farther along. It will probably be many years before San Carlos completely recovers from the evil effects already produced by these "caingins," even if this wanton destruction of timber can be at once stopped, which seems rather doubtful, although some steps are now being taken to keep the practice in check.

The following is a table giving analyses of representative types of soil from this district, together with remarks as to their approximate yield and relative merits according to the local classification.

Soil analyses, district of San Carlos.

Soil No.	Nature of soil.	Fine earth.	K_2O.	Na_2O.	CaO.	MgO.	P_2O_5.	N.	Volatile matter.	Remarks.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
60	Surface	85.8	0.50	0.22	1.64	1.41	0.12	0.22	8.59	Hacienda San Jose. Field near the sea; said to be very fair land, but has suffered much from drought this season; now in plant cane 1 year old; cane very small; estimated yield 40 to 50 piculs (2.53 to 3.16 metric tons) per hectare. Surface soil very dry and cracked by heat; subsoil at 25 centimeters, a little gravel and coarse sand with brownish-yellow clay ins treaks.
60A	Subsoil	79.9	.34	.27	1.84	1.36	.08	.14	7.70	
61	Surface	74.5	.66	.27	1.81	1.42	.13	.21	8.84	Hacienda San Jose. Field near number 60 and similar to it in appearance, but rather more sand and small stones. This field used for first milling test; 1 hectare produces 21.54 metric tons cane and 2.378 metric tons sugar. Cane has suffered much from long-continued dry season.
61A	Subsoil	63.8	.45	.32	1.95	1.92	.12	.18	6.92	
62	Surface	97.5	.57	.22	1.71	1.96	.18	.21	8.36	Hacienda San Jose. High land near river; black loam, a trifle sandy. Good cane land; now in first ratoon crop. Subsoil at 25 centimeters, yellowish clay and a little sand fairly well mixed; a trifle more sand near the river bank.
62A	Subsoil	80	.37	.24	1.93	2.11	.15	.16	8.18	
63	Surface	96.9	.55	.34	2.40	2.41	.22	.22	7.76	Hacienda Providencia. A good cane soil, especially for ratoons. Plant cane said to grow too large and produce poor quality of sugar. Yield about 125 piculs (7.91 metric tons) per hectare from plant cane; part of field near river more or less sandy, while a little higher up somewhat stiffer clay. Subsoil at 30 centimeters, black and yellow clay in streaks with some yellow sand.
63A	Subsoil	97.5	.42	.27	2.50	2.33	.20	.16	7.34	
64	Surface	69.9	.26	.05	1.18	1.23	.08	.31	11.83	Hacienda Providencia. Higher land and near mill. Black clay now in sixth ratoon crop. Estimated will yield 50 to 60 piculs (3.16 to 3.8 metric tons) per hectare. Subsoil at 20 centimeters, white clay with coarse white and yellow sand and pebbles.
64A	Subsoil	77.9	.14	.08	1.01	1.22	.07	.19	10.62	
65	Surface	97.9	.65	.35	2.43	2.24	.24	.29	7.86	Hacienda San Jose. Land near river, considered best soil in the hacienda. Light somewhat sandy loam. Subsoil at 25 to 30 centimeters, clay mixed with sand; at 50 to 60 centimeters, nearly pure yellow sand.
65A	Subsoil	95	.52	.35	2.54	2.24	.21	.07	7.28	

Soil analyses, district of San Carlos—Continued.

Soil No.	Nature of soil.	Fine earth.	K_2O.	Na_2O.	CaO.	MgO.	P_2O_5.	N.	Volatile matter.	Remarks.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
66	Surface	93.9	0.14	0.09	1.11	1.08	0.10	0.14	9.55	Hacienda Refugio. One of the poorest fields, said to yield about 80 piculs (5.06 metric tons) per hectare of No. 1 sugar from plant cane; now in first ratoon; Black cane. Subsoil at 15 centimeters, white clay mixed with some sand.
66A	Subsoil	96.4	.11	.09	1.13	1.13	.09	.10	9.28	
67	Surface	96.7	.22	.29	2.26	1.49	.18	.10	7.81	Hacienda Refugio. Alluvial soil near river back towards mountains; very good land, said to yield 150 piculs (9.50 metric tons) per hectare of No. 3 sugar from plant cane twelve months old. Soil in appearance much like the sandy loams of Ilog-Cabancalan; subsoil at 20 centimeters, clay with much fine sand.
67A	Subsoil	97.8	.17	.30	2.34	1.63	.11	.07	7.87	
68	Surface	99.8	.36	.21	1.89	1.89	.21	.15	8.88	Hacienda Refugio. Best field, near house, said to yield 160 piculs (10.1 metric tons) sugar per hectare from plant cane and practically the same from ratoons. Surface is a rather light loam; subsoil at 20 to 23 centimeters, brown to black clay with a very little sand.
68 A	Subsoil	99.9	.26	.19	1.78	1.69	.23	.10	8.81	
69	Surface	97	.22	.58	1.43	1.18	.14	.12	6.25	Hacienda Refugio. Very poor land near sea; formerly flooded by sea water and probably still influenced by this, as parts of the field are below sea level at high tide. Yield said to be less than 50 piculs (3.6 metric tons) per hectare. Surface soil rather sandy; subsoil at 15 centimeters, very sticky clay.
69A	Subsoil	94	.24	.73	1.32	1.33	.11	.05	5.30	
70	Surface	99.1	.55	.36	3.17	2.30	.14	.14	9.16	Hacienda Fortuna. One of the best fields; said to yield over 100 piculs (6.33 metric tons) per hectare from plant cane. Surface black clay, changing to sandy loam along river bank; subsoil black clay, white clay, and yellow sand, according to distance from river.
70A	Subsoil	99.3	.55	.19	2.83	2.28	.12	.10	8.94	
71	Surface	99.8	.40	.26	5	2.34	.13	.22	9.45	Hacienda Fortuna. Very good cane land; now in second year of ratoons. Surface black clay; subsoil at 20 to 30 centimeters, dark brown clay.
71A	Subsoil	99.8	.46	.14	1.92	2.37	.10	.10	9.24	
72	Surface	99.9	.23	.14	1.56	1	.25	.17	9.55	Hacienda Valle Hermoso. Said to be representative of the soil here. Subsoil at 20 to 30 centimeters, light-colored clay with some sand in places.
72A	Subsoil	99.5	.13	.13	1.65	1.27	.17	.09	7.27	

Soil analyses, district of San Carlos—Continued.

Soil No.	Nature of soil.	Fine earth.	K_2O.	Na_2O.	CaO.	MgO.	P_2O_5.	N.	Volatile matter.	Remarks.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
73	Surface	96.7	0.21	0.18	1.49	1.59	0.15	0.14	7.64	Hacienda Valle Hermoso. This soil not liked as well as number 72, as it is a heavier clay and harder to work; this year, however, it has produced better, owing to the exceptionally dry weather. Subsoil at about 25 centimeters, fairly stiff white clay.
73A	Subsoil	90.3	.20	.15	1.69	1.19	.10	.09	6.80	
84	Surface	95	.64	.31	1.74	1.37	.14	.12	8.04	Hacienda San Jose. Southern part of the hacienda, near sea; formerly swamp land, yield very poor. Surface soil light loam; subsoil at 20 to 25 centimeters, yellow clay with some sand and gravel.
84A	Subsoil	88.2	.52	.37	1.75	1.88	.10	.07	7.11	
85	Surface	95	.44	.31	1.38	.85	.09	.09	4.71	Hacienda San Jose. Southernmost field, near sea and river; very poor soil, especially in dry weather; at best will not yield more than 80 piculs (5.06 metric tons) per hectare from plant cane or half that amount from first ratoons. Surface soil sandy loam; subsoil at 30 centimeters, coarse sand and small stones.
85A	Subsoil	97.9	.37	.32	1.40	.89	.09	.06	4.61	
86	Surface	99.8	.44	.15	1.53	1.73	.11	.10	9.16	Hacienda San Jose. Field in west of hacienda, near mountains; rather poor land, many large stones. Subsoil at 15 to 25 centimeters, stiff brown clay with some sand and small stones.
86A	Subsoil	95.1	.34	.19	1.58	1.83	.09	.07	9.50	
87	Surface	97.4	.24	.07	1.23	1.16	.09	.18	12.60	Hacienda San Jose. Field south and west of number 87; had not been planted for several years until last season; this year nearly all young canes dead from drought. Surface soil rather light loam; subsoil at 15 to 20 centimeters, stiff light yellow clay; at 70 centimeters, many small stones and reddish clay.
87A	Subsoil	98.8	.20	.05	1.26	1.32	.03	.10	11.52	

Soil No.	Nature of soil.	Detritus on 1-mm. screen.	Mechanical analyses of samples (5 grams) of material, district of San Carlos, passing a 1-mm. screen. Samples as prepared for chemical analysis.							
		>1 mm., gravel.	1.0-0.5 mm., coarse sand.	0.5-0.25 mm., medium sand.	0.25-0.10 mm., fine sand.	0.10-0.05 mm., very fine sand.	0.05-0.005 mm., silt.	<0.005 mm., clay.	Total.
60	Surface	14.2	1.64	5.78	9.06	15.00	46.64	21.80	99.92
60 A	Subsoil	20.1	1.20	4.32	9.16	16.78	50.74	18.00	100.20
61	Surface	25.5	3.96	14.28	16.92	14.26	32.92	17.84	100.18
61 A	Subsoil	36.2	8.02	16.92	15.74	13.70	32.60	12.74	99.72
62	Surface	2.5	1.90	7.32	13.10	17.30	44.08	16.76	100.46
62 A	Subsoil	20.0	5.36	13.70	13.84	11.82	34.92	20.22	99.86
63	Surface	3.1	1.66	7.34	13.60	18.66	44.22	13.64	99.12
63 A	Subsoil	2.5	1.90	7.42	13.84	16.44	48.96	12.10	100.66
64	Surface	30.1	5.65	7.33	8.28	11.41	37.19	30.01	99.87
64 A	Subsoil	22.1	2.62	4.72	5.98	7.52	31.82	47.54	100.20
65	Surface	2.1	1.10	7.16	16.06	18.08	45.28	12.26	99.94
65 A	Subsoil	5.0	1.88	9.14	17.08	19.30	40.10	12.02	99.52
66	Surface	6.1	1.60	5.08	9.94	10.82	43.46	28.52	99.42
66 A	Subsoil	3.6	1.84	6.56	11.02	11.40	40.22	28.58	99.62
67	Surface	3.3	1.74	9.14	19.28	22.28	35.60	11.90	99.94
67 A	Subsoil	2.2	1.64	12.14	24.14	18.58	29.76	13.68	99.94
70	Surface	0.9	0.74	5.64	16.04	21.58	42.18	13.34	99.52
70 A	Subsoil	0.7	0.70	5.08	15.82	20.94	40.18	16.68	99.40
71	Surface	0.2	0.28	2.84	13.40	21.94	48.30	13.02	99.78
71 A	Subsoil	0.2	0.23	2.57	15.83	23.34	43.62	14.54	100.13
73	Surface	3.3	1.76	9.40	12.78	11.92	42.22	22.54	100.62
73 A	Subsoil	9.7	1.76	10.07	12.35	12.72	38.36	25.41	100.67
85	Surface	5.0	8.74	37.90	19.52	7.52	16.38	10.44	100.50
85 A	Subsoil	12.1	7.26	37.82	20.52	7.72	14.80	12.18	100.30
87	Surface	2.6	1.54	3.84	8.43	11.74	36.09	38.37	99.99
87 A	Subsoil	1.2	0.95	2.52	5.42	9.85	34.27	46.97	99.97

The average composition of these soils is as follows:

Chemical composition.

Nature of soil.	Fine earth.	K_2O.	Na_2O.	CaO.	MgO.	P_2O_5.	N.	Volatile matter.
	Per cent.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Surface	94.03	0.40	0.24	1.94	1.60	0.15	0.17	8.67
Subsoil	91.17	0.32	0.24	1.80	1.67	0.12	0.11	8.01

Physical composition.

Nature of soil.	>1 mm., gravel.	1.0–0.5 mm., coarse sand.	0.5–0.25 mm., medium sand.	0.25–0.10 mm., fine sand.	0.10–0.05 mm., very fine sand.	0.05–0.005 mm., silt.	<0.005 mm., clay.	Total.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Surface	7.6	2.49	9.47	13.57	15.58	39.58	19.26	99.94
Subsoil	10.4	2.72	10.23	13.90	14.62	36.95	21.59	100.01

Taken as a whole, these may be classed among the most fertile soils of Negros, being exceptionally rich in potash and having a content of lime, phosphoric acid, and nitrogen somewhat above the average. Individually, there is considerable variation, as might be expected in a place which, unlike some of the sugar lands of the west coast, does not lie close along the banks of one large river, but is broken up by many small streams, valleys, and hills, yet, out of the entire series of soils here analyzed, not one could really be called lacking in fertility, as judged by the standards of what constitutes a good cane soil in this island.

Those soils stated by the owners to be relatively poor producers, viz, numbers 66, 85, 86, and 87, while not lacking in potash or lime, are decidedly lower in both phosphoric acid and nitrogen than the majority of fields in this district; still, soils of a similar composition are considered very productive in districts such as Silay or Bago. The unproductiveness of numbers 69 and 84 is undoubtedly occasioned by the deleterious effect of sea water on the roots of the cane, the increased proportion of soda to potash and of magnesia to lime in their subsoils as compared with the surface being pretty good evidence that the lower strata here are at high tide reached by seepage from the ocean. In number 61, also, this effect is indicated, although to a somewhat less marked extent.

On the other hand, the five soils, numbers 63, 65, 68, 70, and 71, are selected as being exceptionally fertile. They are richer than the average in all the chemical elements considered essential to a good cane soil, some of them being especially so as regards lime.

With the exception of the extreme cases just mentioned, differences in productivity must be due to other causes, such as physical characteristics of the soils, time under cultivation, care taken in cultivating and planting, weather conditions, etc. The element of chance, also, is no small factor in sugar growing on many soils. If cane is planted very early, before the rains have stopped, an extra heavy period of rains may ensue late in the season and literally drown out the young cane, especially in heavy, undrained soil, while a late planting may be followed by such excessively dry weather that the plants wither and parch in the ground, and, in sandy soils, are either killed outright or, in heavier ones, have such a poor start that they are unable to stand up before the rains of the next season.

Analyses of sugar cane growing in these soils are given below:

Cane analyses, district of San Carlos.

No.	Remarks.	Average weight per cane.	In cane. Sucrose.	In cane. Fiber.	In juice. Brix.	In juice. Sucrose.	In juice. Quotient of purity.	In juice. Reducing sugar.
		Kilos.	*Per ct.*	*Per ct.*		*Per ct.*		*Per ct.*
39	Plant cane, twelve months old, from soil number 60, hacienda San Jose; has suffered much from drought	0.38	17.32	11.02	22.01	20.04	91.03	0.58
42	First ratoon cane, eleven months old, from soil number 61, hacienda San Jose; has suffered much from drought	0.41	18.01	12.51	23.00	21.21	92.15	0.22
43	First ratoon cane, ten months old, from soil number 62, hacienda San Jose	0.41	18.71	11.24	23.49	21.84	92.96	0.27
44	Plant cane, eleven months old, from soil number 63, hacienda Providencia	0.93	15.29	10.64	20.21	17.71	87.62	1.24
45	Sixth ratoon cane, from soil number 64, hacienda Providencia; about ten months old	0.74	16.47	12.61	22.26	19.73	88.65	1.08
46	Plant cane, 10 months old, from soil number 65, hacienda San Jose	1.06	16.76	9.89	21.33	19.26	90.31	0.85
48	Plant cane, twelve months old, from soil number 67, hacienda Refugio	0.80	15.86	11.03	20.84	18.75	89.91	0.97
49	Plant cane, twelve months old, from soil number 70, hacienda Fortuna	1.00	17.00	11.05	21.44	19.86	92.60	0.49
50	Second ratoon cane, twelve months old, from soil number 71, hacienda Fortuna	0.70	17.67	11.22	22.91	20.73	90.51	0.69
51	Hacienda Valle Hermoso. Canes large and many fallen down	1.13	15.58	10.80	20.96	18.06	86.16	1.35
	Average	0.76	16.87	11.20	21.85	19.72	90.19	0.77

These samples differ somewhat from those obtained in other localities, in that they contain more fiber and a juice somewhat more concentrated and richer in sugar. The purity of the juice and its percentage of reducing sugar is about the same as in other districts. It is difficult to account for the increase in fiber found here, as the same variety of cane is grown in San Carlos as in other parts of Negros, except on the theory that the droughts prevalent in this section of the island during the past few years have caused a partial drying out of the cane; this would also explain the greater density and sweetness of the juice.

The first three samples examined have undoubtedly been thus affected, since they have been so stunted in their growth by dry weather as to be only about half the ordinary size. The large amount of alkalies and alkaline earths in these soils may also have a tendency, when concentrated by drought, to check the growth of the cane. Number 45 probably owes its high fiber in a large degree to the length of time it has been allowed to grow without replanting, ratoons of many years' standing apparently showing a tendency toward a harder, more

woody growth. Neither this nor number 44 were quite mature when cut. An excessively dry spell at the time forced many planters to cut fields which were not yet ripe in order to save them from total loss, especially in the case of much cane planted late in the previous year, which had not attained sufficient maturity to enable it to withstand the severe heat and dryness, and was withering in the fields without ever becoming fully ripe. Number 46 was taken from a field similarly affected. Although one of the best soils on the hacienda under normal conditions, it had so badly suffered from drought this year that probably 20 per cent of the cane growing on it was either too green to cut or was dead and partially decayed. The canes taken for analysis, being selected with the view of securing only fairly mature specimens, are apparently very good, although a little young, ten months old, but canes from the same field which were being ground at the mill at this time and could not be so carefully selected, despite instructions which had been given to throw out dead canes as much as possible, yielded a mill juice of the following composition: Brix, 16.75; sucrose, 13.46; purity, 80.34—which of course produced a very poor quality of sugar.

Number 49 is from one of the best fields I have seen in Negros, the cane itself being large and quickly grown, yet erect and of very good quality. Soil number 70, from this field, is very high in potash and lime, but only moderately so in phosphoric acid and nitrogen.

Number 51 is an analysis of cane from a field of very luxuriant growth; in fact, much of it had fallen down so badly that the cane, although thirteen months old, had not been able to ripen as it should, and as a consequence had suffered somewhat in quality. The soil from which it came, although very good, does not on analysis show any extraordinary richness.

BAIS.

About 100 kilometers south of San Carlos, or ten hours' sail by water, lies Bais, the only important sugar district in the Province of Oriental Negros, 43 kilometers north, by the provincial road, from Dumaguete, the capital. The harbor of Bais, the best in Negros, is formed by a fairly deep indentation in the coast line and is well protected from rough weather at all times of the year by two small islands directly at its entrance and by its proximity to the Island of Cebu, which at this point is only 16 kilometers distant. At present it is only available for vessels of comparatively light draft, as it only contains 3 or 4 meters of water at low tide anywhere within a kilometer of the shore. Transportation to Iloilo follows the same route as from San Carlos, but, owing to the longer distance to be carried, freight rates on sugar are somewhat higher, averaging 30 centavos per picul (4.75 pesos per metric ton). Some lorchas load at a small dock on a projecting point of land near the town, others at private landings on the haciendas. The haciendas of Bais are not spread out over so great an area as in other districts, but are fairly well crowded together in a level plain nearly surrounded by mountains, having a total extension north and south of 6 kilometers, and inland from the coast from 2 to 3 kilometers, a large proportion of this area being cultivable sugar land. Thirteen kilometers south of Bais is the barrio of Tanjay, containing

some thousand hectares of fairly good sugar land, little of which is at present under cultivation, while 10 kilometers to the north is located the barrio of Manjuyod, with approximately the same amount of land, also uncultivated. Several small streams run through the district, but are of no use for navigation. Land transportation, aside from that along the provincial road to Dumaguete, is restricted to private roads kept up by the individual haciendas.

Area and production of the district of Bais (1908).

	Amount.	
	Hectares.	*Per cent.*
Number of growers, 18.		
Area of growers' land planted in sugar cane	1,688	58.9
Area of growers' land suited to cane culture but not planted	1,157	40.4
Other land suited to cane culture but not planted	20	0.7
Total sugar land	2,865	
Average amount of sugar land in hectares owned by each grower:		
Planted	93.8	
Unplanted	64.3	
Total	158.1	
	Piculs.	*Metric tons.*
Average amount of sugar produced by each grower	4,251	268.8
Average amount of sugar produced per hectare planted	45.3	2.87
Total sugar produced	76,509	4,839

Since the individual grower here owns more land and has a larger amount under cultivation than in the majority of other parts of Negros, he naturally produces a relatively greater amount of sugar, being in this respect second only to the average grower of San Carlos, but the yield per hectare of land planted is only a trifle higher than the general average for the island and less than half of what it should be in a district so fertile as Bais. As in other regions, much of the land here reported to be planted in sugar cane is, for the greater part through lack of capital, so poorly cared for that the apparent yield per hectare of the district as a whole is thereby considerably reduced.

The sugar soils of Bais are in general appearance and chemical composition much like those of Ilog-Cabancalan, which lies just across the mountains on the opposite side of the island, and are locally classified into the same three main types according to texture, those of Bais running perhaps more to the "tierra mestiza" and heavy clay lands, the latter being termed on this side of the island "lamákan" instead of "bankil." The following analyses of soils taken from different haciendas throughout the entire district represent very well the average composition of the sugar lands of Bais:

Soil analyses, district of Bais.

Soil No.	Nature of soil.	Fine earth.	K_2O.	Na_2O.	CaO.	MgO.	P_2O_5.	N.	Volatile matter.	Remarks.
		Per ct.	*Per ct*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
74	Surface	100.0	0.38	0.40	3.61	2.35	0.22	0.17	10.10	Hacienda Rosario. A composite sample from four different fields, but all very much the same in appearance; said to yield up to 150 piculs (9.50 metric tons) sugar per hectare. Surface soil sandy loam ("tierra bombon"); subsoil at 25 to 30 centimeters, a mixture of fine yellow sand and some clay; at 60 centimeters, nearly all sand. Cane is said to grow well in this soil even in very dry or in very wet weather.
74 A	Subsoil	100.0	.25	.22	6.61	2.22	.15	.11	10.10	
75	Surface	100.0	.43	.28	3.20	2.22	.24	.16	10.82	Hacienda Tamugun, farther back toward the mountains. "Tierra mestiza," somewhat heavier soil than number 74; very good cane land; subsoil at 30 to 35 centimeters, very little different from surface; at 65 centimeters, heavy black clay.
75 A	Subsoil	100.0	.33	.18	2.97	1.98	.14	.13	9.72	
76	Surface	99.9	.27	.12	3.19	1.89	.15	.16	13.30	Hacienda Paz. Light clay loam, good cane soil; subsoil at 25 centimeters, black clay.
76 A	Subsoil	99.9	.25	.10	3.08	1.94	.11	.12	11.67	
77	Surface	97.8	.40	.40	2.91	2.19	.19	.13	9.50	Hacienda Consolacion. "Tierra mestiza," surface black clay loam; subsoil mixture of black clay and yellow sand; said to yield 90 to 100 piculs (5.70 to 6.33 metric tons) per hectare.
77 A	Subsoil	98.7	.27	.48	5.27	2.21	.16	.10	9.42	
78	Surface	94.4	.46	.51	2.91	1.98	.20	.14	10.34	Hacienda Valencia. A mixed soil, very similar to number 77.
78 A	Subsoil	96.0	.28	.25	5.24	2.08	.15	.10	9.60	
79	Surface	98.8	.29	.10	.85	1.46	.09	.12	10.40	Hacienda Pilar. "Lamákan" heavy black clay, uncultivated at present; said to produce good quality of cane, but rather small. In very wet years cane does not grow well, owing to lack of drainage; subsoil at 20 centimeters, very stiff black clay.
79 A	Subsoil	99.1	.31	.08	1.00	1.77	.07	.09	10.47	
80	Surface	99.3	.26	.06	1.68	1.55	.11	.19	11.93	Hacienda Pilar, land near sea. Said to be very good cane land in dry years, but somewhat doubtful if much rainfall; has some drainage toward sea; subsoil at 20 centimeters, stiff black clay.
80 A	Subsoil	99.8	.21	.08	1.78	1.62	.06	.09	11.38	
81	Surface	100.0	.32	.23	6.52	2.38	.13	.12	10.60	Hacienda Cambuilao. Black clay soil; very good land; subsoil at 30 centimeters, yellow clay.
81 A	Subsoil	100.0	.26	.22	5.39	2.24	.14	.11	9.76	
82	Surface	97.6	.42	.31	2.53	2.01	.17	.14	10.29	Hacienda Tankulugan, northern part of Bais. "Tierra mestiza" or "mixed" soil; subsoil at 25 centimeters, yellow clay and fine sand; at 55 centimeters, nearly all sand, some rather coarse.
82 A	Subsoil	88.0	.24	.31	5.66	2.06	.14	.08	9.27	
83	Surface	100.0	.40	.22	2.36	1.93	.19	.14	10.44	Hacienda Biñojon, northern part of Bais, near seacoast. Surface soil similar to number 82; subsoil somewhat finer sand and rather more clay in proportion.
83 A	Subsoil	100.0	.28	.23	3.90	2.20	.15	.11	9.81	

Soil No.	Nature of soil.	Detritus on 1-mm. screen. >1 mm., gravel.	Mechanical analyses of samples (5 grams) of material, district of Bais, passing a 1-mm. screen. Samples as prepared for chemical analysis. 1.0–0.5 mm., coarse sand.	0.5–0.25 mm., medium sand.	0.25–0.10 mm., fine sand.	0.10–0.05 mm., very fine sand.	0.05-0.005 mm., silt.	<0.005 mm., clay.	Total.
74	Surface	0.0	0.44	1.76	9.20	29.36	45.52	14.22	100.50
74A	Subsoil	0.0	0.43	2.64	12.69	28.69	45.18	10.79	100.48
76	Surface	0.1	0.14	0.80	8.74	15.24	50.88	23.64	99.44
76A	Subsoil	0.1	0.24	0.94	12.80	19.32	43.00	23.42	99.72
79	Surface	1.2	1.05	2.86	5.15	4.57	43.53	42.41	99.60
79A	Subsoil	0.9	0.66	2.18	4.92	5.76	50.89	36.12	100.53
80	Surface	0.7	0.12	0.84	4.98	11.12	43.88	39.12	100.06
80A	Subsoil	0.2	0.14	0.76	6.22	13.68	49.80	29.66	100.26
83	Surface	0.0	0.10	0.80	8.98	26.50	47.92	15.72	100.02
83A	Subsoil	0.0	0.10	0.96	12.94	33.40	41.78	11.26	100.44

Chemical composition.

Nature of soil.	Fine earth.	K_2O.	Na_2O.	CaO.	MgO.	P_2O_5.	N.	Volatile matter.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Surface	98.78	0.36	0.26	2.98	2.00	0.17	0.15	10.77
Subsoil	98.15	0.27	0.22	4.09	2.03	0.13	0.10	10.12

Physical composition.

Nature of soil.	>1 mm., gravel.	1.0–0.5 mm., coarse sand.	0.5–0.25 mm., medium sand.	0.25–0.10 mm., fine sand.	01.0–0.05 mm., very fine sand.	0.05-0.005 mm., silt.	<0.005 mm., clay.	Total.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Surface	0.4	0.37	1.41	7.40	17.36	46.35	27.03	99.92
Subsoil	0.3	0.32	1.50	9.91	20.17	46.13	22.25	100.28

Practically all the soils of Bais are locally considered to be excellent sugar producers, and the same fact is indicated by chemical analysis, they being especially rich in potash and lime and somewhat above the average in phosphoric acid and nitrogen. As in Ilog-Cabancalan, much of the lime is present as the carbonate. Apparently, Bais has an abundant yearly rainfall, as I am informed that the cane there hardly ever suffers from drought, the only complaint being that in especially wet years, cane growing in the "lamákan" soils is apt to be injured by the abundance of water, which does not filter well through the heavy clay subsoil. To obviate this danger it is customary to commence planting rather early, so as to finish before March at the latest, and get a good stand of cane before the onset of the rainy season

in June or July. Efficient canalization also is found to be of great help in reducing the loss occasioned by water stagnating on the fields.

Just one soil of the entire district, number 79, is reported as being unproductive for sugar growing. In the past it has been cultivated to a certain extent, but never successfully except in extremely dry years, when it is said to produce a cane small in size, but of very good quality. Several years ago the owner sustained such severe losses through having almost the entire crop of cane planted on this land killed by too much rain, that some 400 hectares of it have been completely abandoned as far as sugar raising is concerned. Analysis shows this soil to be fairly rich in everything except lime, in which it is very deficient compared with other soils of the district. In physical composition it is shown to contain more clay and silt, and less sand than the soil from other parts of the district An attempt is now being made to improve this field by means of deep drainage ditches as a protection against stagnant water. Judging from the surrounding country, it is quite possible that treatment with lime up to 10 or even more tons per hectare might be of great help in loosening up this soil and destroying the plasticity of the clay, although of course the value of such treatment could only be determined with certainty by actual tests on small portions of the field itself.

At the time of my visit to Bais all of the estates had finished grinding. It was therefore impossible to procure samples of cane for analysis; but, according to statements made by the planters, the cane here presents no marked difference from that found in other portions of Negros. The proportion of plant cane to ratoons is said to be about the same as in Ilog-Cabancalan.

THE SOIL OF NEGROS COMPARED WITH THAT OF OTHER SUGAR-PRODUCING COUNTRIES.

AVERAGE COMPOSITION OF NEGROS SOIL.

The following table shows compactly the average composition of the surface and the subsoils of each of the important sugar districts of Negros, together with the general average for the entire island:

Average composition of the sugar soils of Negros.

SURFACE SOILS.

No.	District.	Fine earth.	K_2O.	Na_2O.	CaO.	MgO.	P_2O_5.	N.	Volatile matter.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1	Silay, etc	98.17	0.05	0.09	0.52	0.45	0.09	0.11	6.55
2	Bago	98.43	.11	.07	.38	.25	.10	.10	9.57
3	Pontevedra-La Carlota	93.03	.14	.20	.79	.31	.17	.17	10.68
4	Binalbagan-Isabela	99.76	.15	.18	1.50	.88	.20	.14	10.01
5	Ilog-Cabancalan	99.51	.21	.20	3.51	1.34	.19	.13	8.91
6	San Carlos	94.03	.40	.24	1.94	1.60	.15	.17	8.67
7	Bais	98.78	.36	.26	2.98	2.00	.17	.15	10.77
	General average	97.39	0.20	0.18	1.66	0.98	0.15	0.14	9.31

SUBSOILS.

No.	District.	Fine earth.	K_2O.	Na_2O.	CaO.	MgO.	P_2O_5.	N.	Volatile matter.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1	Silay, etc	96.04	0.04	0.09	0.52	0.45	0.6	0.09	8.29
2	Bago	98.47	.11	.07	.41	.23	.08	.07	10.08
3	Pontevedra-La Carlota	89.60	.14	.22	.88	.32	.14	.11	10.09
4	Binalbagan-Isabela	99.76	.13	.14	1.45	.91	.15	.10	10.10
5	Ilog-Cabancalan	99.52	.19	.21	3.36	1.31	.17	.09	7.67
6	San Carlos	91.17	.32	.24	1.80	1.67	.12	.11	8 01
7	Bais	98.15	.27	.22	4.09	2.03	.13	.10	10.12
	General average	96.10	0.17	0.17	1.79	0.99	0.12	0.10	9.19

Mechanical analyses of Negros soils; averages for the different districts.

SURFA CE SOILS.

No.	District.	Detritus on 1-mm. screen.	Analyses of samples (5 grams) of material passing a 1-mm. screen. Samples as prepared for chemical analysis.						
		>1 mm., gravel.	1.0-0.5 mm., coarse sand.	0.5-0.25 mm., medium sand.	0.25-0.10 mm., fine sand.	0.10-0.05 mm., very fine sand.	0.05-0.005 mm., silt.	<0.005 mm., clay.	Total.
1	Silay, etc	2.2	0.94	4.74	14.76	23.48	33.59	22.20	99.71
2	Bago	1.0	1.53	7.05	12.70	21.30	34.04	23.28	99.91
3	Pontevedra-La Carlota	7.0	3.03	10.33	12.66	13.49	34.66	25.93	100.10
4	Binalbagan-Isabela	0.2	0.39	3.18	11.07	15.87	48.74	20.51	99.75
5	Ilog-Cabancalan	0.2	0.13	1.61	13.27	29.53	42.27	13.42	100.22
6	San Carlos	7.6	2.49	9.47	13.57	15.58	39.58	19.26	99.94
7	Bais	0.4	0.37	1.41	7.40	17.36	46.35	27.03	99.92
	General average	2.7	1.27	5.40	12.20	19.51	39.89	21.66	99.94

SUBSOILS.

1	Silay, etc	3.3	0.90	4.49	14.20	21.24	33.31	25.83	99.97
2	Bago	0.8	1.25	5.86	13.99	19.65	33.91	25.21	99.86
3	Pontevedra-La Carlota	12.0	3.89	11.85	13.04	11.30	33.43	26.69	100.21
4	Binalbagan-Isabela	0.3	1.05	3.58	10.45	19.94	43.91	20.85	99.75
5	Ilog-Cabancalan	0.3	0.21	2.87	16.67	24.74	42.36	12.91	99.76
6	San Carlos	10.4	2.72	10.23	13.90	14.62	36.95	21.59	100.01
7	Bais	0.3	0.32	1.50	9.91	20.17	46.13	22.25	100.28
	General average	3.9	1.48	5.77	13.17	18.81	38.57	22.19	99.99

Considered as a whole, they may be said to be decidedly high in lime, but only moderately so, although containing an ample sufficiency in potash, phosphoric acid, and nitrogen for profitable sugar-cane growing. As all but a small percentage of the entire soil is "fine earth"—that is, the portion passing a sieve 1 millimeter in diameter, which is

taken as the final sample upon which the analyses are based—it follows that in a given area of land considerably more nutritive matter is actually present than in a land of coarser texture, where the fine earth might amount to only 30 to 40 per cent of the whole, even though the latter appeared on analysis to be somewhat richer.

HAWAIIAN SOILS.

Below is given the average analysis of soils in the Hawaiian Islands:[7]

Island.	Potash.	Lime.	Phosphoric acid.	Nitrogen.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Kauai	0.358	0.504	0.237	0.246
Hawaii	0.353	0.833	0.320	0.388
Oahu	0.348	0.411	0.269	0.119
Maui	0.401	0.691	0.200	0.222
General average	0.365	0.609	0.256	0.243

Omitting the third decimal place as a rather unnecessary refinement in soil analysis, it will be noted that these Hawaiian soils, which under intensive cultivation and irrigation are the most highly productive in the world, run from one and a half to two times higher in potash, phosporic acid, and nitrogen than the general average of soils from Negros, although their superiority is not so marked when compared with the richer districts of San Carlos and Bais. In lime they are very much lower.

EGYPTIAN SOILS.

Analyses of the narrow strip of alluvial soil along the Nile, in upper Egypt, where much sugar cane is grown, are given by Tiemann:[8]

Locality.	K_2O.	Na_2O.	CaO.	MgO.	P_2O_5.	N.	Loss in calcinating.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Cheik Fadl	0.88	0.89	5.31	2.79	0.23	0.04	4.82
Do	1.33	0.95	5.84	3.14	0.38	0.04	5.49
Charkieh	0.72	1.31	3.34	1.99	0.25	0.48	6.62
Do	0.87	1.16	2.27	2.95	0.37	0.21	8.38
Yellow earth at Beni Mazar	0.7	0.56	4.36	1.76	0.21	0.66	4.21
Black earth at Beni Mazar	1.88	2.16	3.39	2.57	0.29	0.43	6.9
Average	1.06	1.17	4.09	2.53	0.29	0.31	6.07

Although these are decidedly richer in every respect than the famous Hawaiian soils, yet they are spoken of by Tiemann as being "exhausted" and in need of artificial fertilizers, a fact which would tend to support the theory that the so-called "exhaustion" of soils is more often than not due to other causes than simply a lack of sufficient mineral plant food.

[7] Report of Work of the Experiment Station of the Hawaiian Sugar Planters' Association, Div. of Agr. and Chem. Bull. No. 15, 1905, p. 7.

[8] The Sugar Cane in Egypt, p. 18.

The following analyses of sugar soils collected from various sources are quoted from Deer, "Sugar and the Sugar Cane."

LOUISIANA SOILS.[a]

Potash.	Soda.	Lime.	Magnesia.	Phosphoric acid.	Nitrogen.
Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
0.092	0.158	0.394	0.087	0.068	0.097
0.162	0.142	0.313	0.025	0.126	0.130
0.233	0.081	1.494	0.039	0.098	0.060
0.747	0.181	0.910	1.361	0.146	0.085

[a] Quoted originally by Stubbs in "Sugar Cane."

Stubbs concludes that the average composition of Louisiana soils is lime, 0.5 per cent; potash, 0.4 per cent; phosphoric acid, 0.1 per cent; nitrogen, 0.1 per cent.

JAVA SOILS.[a]

Sand.	Calcium carbonate.	Lime.	Magnesia.	Potash.	Phosphoric acid.	Nitrogen.
Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per. ct.*	*Per. ct.*
9.6	1.38	2.52	0.18	0.14	0.19	0.08
26.2	0.02	0.95	0.19	0.12	0.11	0.07
53.4	0.02	2.21	0.17	0.06	0.07	0.06
40.2	0.05	2.48	0.26	0.05	0.07	0.14
45.6	0.00	1.08	0.17	0.05	0.04	0.03
4.2	0.02	0.68	0.10	0.05	0.06	0.09

[a] By Kramers, and quoted by Kruger in "Das Zuckerrohr."

These soils are considered decidedly poor in every constituent except lime, and yet Java is producing from them, by scientific methods of cultivation, over 10 metric tons of sugar per hectare per annum, over three and one-half times the present yield in Negros.

DEMERARA SOILS.[a]

The first had been in cultivation for five and the second for over sixty years. The third is a Queensland soil quoted from the same source.

Potash and soda combined.	Lime.	Magnesia.	Phosphoric acid.
Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
0.11	0.64	0.50	0.08
0.10	0.11	0.36	0.05
0.20	0.56	0.26	0.06

[a] Analyzed by Phipson and quoted by Locke and Newlands.

SOILS FROM BERBICE.[a]

Nature of soil.	Potash and soda combined.	Lime.	Magnesia.	Phosphoric acid.	Nitrogen.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1. A heavy clay, under cultivation for a number of years	0.50	0.27	0.15	0.19	0.05
2. Virgin forest soil	0.53	0.28	0.17	0.19	0.97

[a] Analyzed by Deer.

MAURITIUS SOILS.[a]

Lime.	Potash.	Phosphoric acid.
Per cent.	*Per cent.*	*Per cent.*
0.419	0.199	0.156
0.475	0.188	0.129
0.389	0.155	0.105
0.163	0.121	0.221

[a] Analyzed by Deer.

COMPARISON OF NEGROS SOILS WITH THOSE OF OTHER COUNTRIES.

Comparing all these soil analyses, it will be seen that, although not preëminently rich in most constituents, the soil of Negros may rightfully be classed as among the better of the sugar lands of the world, and, given the proper care in cultivation, should be able to yield eventually as much sugar in proportion to the area of ground planted as any other country depending for its supply of water on its natural rainfall. Practical experience in cane culture tends to establish the fact that production depends more upon careful and intelligent cultivation than upon any inherent richness in plant food possessed by the soil itself, granted, of course, as a starting point a land not utterly deficient in these necessary elements of nutrition. An example of the truth of this statement is the relative productivity of different parts of the Hawaiian Islands. In comparing different sugar-producing countries, Hawaii is almost invariably placed in the lead without a rival, because of "the enormous fertility of her soil," both fertility and average yield being often grossly exaggerated.

Geerligs [9] gives statistics regarding the total production of the Hawaiian Islands in recent years, from which it is seen that the average yield of all the land under cultivation during the ten years ending with 1906 was 9.997 metric tons per hectare; the arid portions of the islands, provided with expensive irrigation

[9] De Rietsuikerindustrie in de verschillende landen van Productie. *De Indische Mercuur* (1909), 32, 897.

systems, produced in the same time 13.133 metric tons per hectare, while those parts depending on natural rainfall averaged only 7.241 metric tons per hectare. This latter figure, corresponding to about 115 piculs per hectare, is nearly three times the average yield in Negros, but is often equaled and even exceeded on fields of considerable extent in some of the better cultivated plantations, not only in the richer, but also in the poorer soils of the island. Java, with a soil much poorer than that of Negros, yields on the average fully as much sugar per hectare as the Hawaiian Islands. The Island of Hawaii, which is largely dependent on rain, but little irrigation being practiced, averages, in production per extent of land planted, about half as much as the well-irrigated Oahu. From the analyses of Hawaiian soils previously quoted, it is shown that the soil of Hawaii is chemically decidedly superior to that of Oahu. Geerligs goes on to state that "it is seen, on the whole, that the soil of the Hawaiian Islands does not give such an enormously high yield of sugar as is commonly attributed to it by writers on the subject. The popular impression to the contrary comes from the fact that there are in the neighborhood of Honolulu (on the Island of Oahu) a few estates of extra fertile land, especially well cultivated and provided with perfect irrigation plants, so that here extraordinarily large crops of cane and sugar are produced. As the majority of tourists do not get any farther away than the outskirts of Honolulu, the conditions existing there are too readily generalized, and reports come out that in Hawaii they get 12 tons of sugar per acre—that is, 26.88 metric tons (430 piculs) per hectare." [10]

While Negros, handicapped as it is by severe tropical rains during a large part of the year, may never hope to rival the irrigated lands of the Hawaiian Islands, where water is supplied only when needed, there is no reason why it should not eventually produce fully as much sugar per hectare as the non-irrigated portion of that country, provided it is found profitable to expend the same amount of care and money in cultivation and fertilization.

FERTILIZATION IN NEGROS.

The great majority of planters in Negros at the present time pay absolutely no attention to fertilizing the soil, but reap crop after crop with apparently no thought for the future. In some of the less productive, districts, such as Silay and parts of Bago and La Carlota, diminishing yields are beginning to force this subject to their attention, and some attempts are being made toward improving the soil, chiefly by means of animal manure, a poor field being fenced off for a season and used as a "toril" or inclosure for the work animals. In a few places, also, the necessity of returning scums and bagasse ashes to

[10] It is needless to state that the Hawaiian planters are in no way responsible for these exaggerated reports. Accurate data concerning the sugar production there have always been available to anyone who cared to take the trouble to look them up. Mr. Geerlig's remarks upon the subject are quoted here, not in any disparagement of Hawaii, but rather to correct the impression, too prevalent among the planters of Negros, that such enormous yields are the general rule in other sugar-producing countries, and therefore would be possible here were similar methods of cultivation and manufacture to be followed.

the fields is becoming appreciated, although the latter are more frequently used for improving the "plaza" and the roads near the mill. Lime is sometimes employed, although to a very limited extent. In one place I was informed that several fields had recently been treated with slaked lime to the extent of about 200 liters per hectare. When asked with what object, the native foreman replied that the cane from these fields yielded a juice which required an excessive amount of lime for its defecation; his idea being to save lime in the sugar house by adding it to the soil! The use of artificial fertilizers is almost unknown, this not being the fault of the planters so much as because thus far no reliable fertilizers have been offered for sale in the Iloilo market at prices anywhere nearly commensurate with their real value. The amount of mineral matter removed from the soil by a crop of sugar cane is not excessive, and, provided the greater part of this is returned to the fields each year in the form of bagasse ash and factory waste, there is apparently very little need of extra fertilizers if these are considered simply as a means of replenishing plant food in the soil.

Analyses of bagasse ash from different parts of Negros indicate that the cane grown there is comparatively low in mineral matter, as might be expected from its low fiber content. Three samples of bagasse ash collected by me from mills in the districts of Bago, Ilog-Cabancalan, and San Carlos were analyzed by Mr. R. R. Williams, of the Bureau of Science, with the following results:

Analyses of bagasse ash.

Constituents.	1. Hacienda Lumañgub, Bago, Occidental Negros.	2. Hacienda San Isidro, Cabancalan, Occidental Negros.	3. Hacienda San Jose, San Carlos, Occidental Negros.
	Per cent.	*Per cent.*	*Per cent.*
Water (H_2O) at 110°	0.77	0.68	1.32
Loss on ignition[a]	1.43	1.04	4.61
Silica (SiO_2)	63.91	68.50	64.27
Ferric oxide and alumina ($Fe_2O_3+Al_2O_3$)	15.22	10.22	11.42
Lime (CaO)	4.27	5.79	3.85
Magnesia (MgO)	2.54	1.96	2.83
Potash (K_2O)	8.14	8.28	8.16
Soda (Na_2O)	4.13	3.66	3.20
Phosphoric acid (P_2O_5)	0.60	0.60	0.59
Sulphuric acid (SO_3)	0.08	0.15	0.13
N	0.01	0.01	0.03
Total	101.09	100.88	100.38

[a] All the samples contained ferrous iron to such an extent that many particles of ash were attracted by the magnet. As no determination of ferrous iron was possible on account of carbonaceous matter, no correction has been made in totalling.

These samples do not vary in composition to as great an extent as might be expected, when it is considered that the soils in which these canes were grown are of widely different chemical composition, especially as regards their content of potash. Since no data are at present available as to the ash of the entire cane, which may vary decidedly from that of the bagasse, it is impossible to calculate even approximately the amount of mineral matter taken from the soil by the Negros cane.

Deer[11] quotes from Stubbs, who, from experiments covering a period of ten years, calculates the amount in pounds of mineral matter removed per ton of the Lousiana Purple cane as follows:

Nitrogen	2.98
Phosphoric acid	1.63
Potash	2.52
Lime	2.54

Expressed in kilograms per metric ton of cane, these figures would correspond to:

Nitrogen	1.33
Phosphoric acid	0.73
Potash	1.12
Lime	1.13

Assuming a crop of 6 metric tons or 95 piculs of sugar, a little over twice the present average in Negros, which would correspond roughly to 60 metric tons of cane, there would be removed from the soil annually in kilograms per hectare of land the following amounts of mineral matter:

Nitrogen	79.8
Phosphoric acid	43.8
Potash	67.2
Lime	67.8

Now, in 1 hectare of land, from the surface to a depth of 20 centimeters, or the average depth to which the cane roots penetrate, there are 2,000 cubic meters of soil of an approximate apparent specific gravity of 1.5, or 3,000,000 kilos. One-hundredth of 1 per cent of this, the smallest difference which can be detected by an accurate chemical analysis, would amount to 300 kilograms of any one element, so it may be readily seen that at least five, and more probably ten, years would be required before any depletion of the soil from successive crops of sugar cane would be suggested by chemical analyses, even if absolute accuracy in sampling and in analytic methods were assumed, not to mention the greater changes which might be brought about during such a long period of time by mineral matter carried up from greater depths by the soil water, or carried away by rains.

These figures make no pretense at even moderate accuracy, but serve to illustrate the relatively small order of magnitude of changes in the composition of a soil which may be brought about by the cultivation of sugar cane. It is likewise apparent that the ordinary commercial fertilizers would need to be used in quantities of many tons to the

[11] *Loc. cit.*

hectare before any improvement in the soil as regards its actual composition could be detected. This should not be construed as an argument against the use of fertilizers, for they are undoubtedly at times of great benefit, even in very fertile soils, but the way in which they act and indications for their use, although the matter has been carefully studied for many years in all parts of the world, are very little understood.

Cameron[12] states the most modern views on this subject as follows: "Soil chemistry is a very complex subject, into which we are just beginning to get glimpses, and the supply of mineral nutrients is only one of the important details in a very intricate problem. * * * It is of course patent to everyone that fertilizers sometimes, in fact frequently, produce larger crop yields. Sometimes the contrary is true, but it is absolutely certain that at the present time no one can, nor are there any methods available by which one can, safely predict what fertilizers and how much should be used."

It would appear, then, that the question of the extent to which fertilizers may profitably be employed on the soils of Negros, or of any other sugar-producing country, is largely one of bookkeeping rather than of chemistry and can be determined for a given locality only by actual field experiments in that locality, and by the profit-and-loss accounts of the plantations on which these experiments are made.

THE CANE OF NEGROS.

AVERAGE COMPOSITION OF THE SUGAR CANE OF NEGROS.

The following table is deduced from the previously quoted analyses of the common purple or native cane found in four of the most important districts of Negros:

Average composition of the purple or native cane in Negros.

District.	Average weight per cane.	In cane.		In juice.			
		Sucrose.	Fiber.	Brix.	Sucrose.	Quotient of purity.	Reducing sugar.
	Kilos.	*Per cent.*	*Per cent.*		*Per cent.*		*Per cent.*
Bago	1.00	16.41	9.80	20.49	18.80	91.70	0.62
Pontevedra-La Carlota	1.14	14.01	9.30	17.91	15.79	87.99	0.99
Ilog-Cabancalan	0.79	16.95	9.81	21.18	19.30	91.67	0.49
San Carlos	0.76	16.87	11.20	21.85	19.72	90.19	0.77
Average	0.92	16.06	10.02	20.35	18.40	90.38	0.71

Since the purple variety is the only one grown to any extent in Negros, the above represents with a fair degree of accuracy the general run of sugar cane which may be encountered throughout the island. Below are given analyses of other varieties found in Negros. They are

[12] The Dynamic Viewpoint of Soils. *Jour. Ind. and Eng. Chem.* (1909), 810.

practically of no importance except for purpose of comparison, as, with the exception of a few fields of the black cane, they are at the present time only of occasional occurrence or cultivated solely in a few experimental fields.

Other varieties of cane grown in Negros.

No.	Average weight per cane.	In cane. Sucrose.	In cane. Fiber.	In juice. Brix.	In juice. Sucrose.	In juice. Quotient of purity.	In juice. Reducing sugar.	Remarks.
	Kilos.	*Per ct.*	*Per ct.*		*Per ct.*		*Per ct.*	
2	1.94	10.13	11.03	14.66	11.72	79.97	1.43	From experimental plot, Bureau of Agriculture experimental station, La Granja; soil number 4; variety, plant cane eleven and one-half months old, Hawaiian "Rose Bamboo."
3	1.10	10.08	10.02	13.88	11.39	82.00	1.07	Same soil and conditions as number 2; variety, Hawaiian "White Bamboo."
4	0.91	13.43	9.53	17.34	15.05	86.82	1.02	Same soil and conditions as number 2; variety, "Demerara 95."
5	1.34	12.96	11.80	17.62	15.24	86.50	1.10	Same soil and conditions as number 2; variety, "Tiboo Mird."
7	1.64	13.49	9.49	17.59	15.41	87.62	1.01	Same soil and conditions as number 2; variety, "Louisiana Striped."
8	1.00	15.31	11.26	19.48	17.95	92.15	0.61	"Caña Negra" or black cane, from hacienda Carmen Chica; said to be a native variety, sometimes found growing wild in the mountains. The natives use a decoction of the rind as a medicine.
9	1.43	12.20	8.37	16.18	13.75	84.96	0.88	Said to be third ratoon from Hawaiian Rose Bamboo; soil number 3, La Granja; canes apparently not fully mature.
11	1.61	13.84	10.41	17.50	15.91	90.88	0.71	Same field as number 9, but ripe canes selected.
30	0.78	15.05	11.80	20.88	17.54	83.99	1.76	Native "white" or rather yellowish canes, from soil number 17, hacienda Lumangup, Bago. This variety is of infrequent occurrence and is never planted here.
40	0 50	12.27	15.48	18.26	15.07	82.52	1.62	A peculiar wild variety called "Sagao," said to occur only in the San Carlos district; very erect and slender, like a reed, with long joints; never planted, as it is very hard and apt to break the mill; grows well and resists drought.
41	0.78	15.62	14.07	20.92	19.18	91.70	0.39	Third ratoon black cane from hacienda Providencia, San Carlos. The original seed cane said to have been imported from Java; generally yields No. 1 sugar, although dark colored.
47	0.55	14.60	14.63	19.89	18.23	91.64	0.37	First ratoon black cane from soil number 66, hacienda Refugio, San Carlos; fourteen months old.
27	2.01	10.10	8.05	15.35	11.18	72.85	2.11	First ratoon native cane from soil number 21, hacienda Lumangup, Bago. Canes very large and thickly grown, but most of them twisted, fallen over, and lying along the ground like vines; soil is said to be too rich for the cane.

The first five are varieties of canes grown in the small experimental plot at the Bureau of Agriculture experiment station at La Granja. They are much larger in size than is the rule in Negros, but are relatively poor in sucrose and purity and contain a large amount of reducing sugar. That these are not inherent qualities of the cane itself, but rather the effect of the soil in which they grow, is shown by comparing a native cane from the same plot, number 6, quoted in the table of canes from Pontevedra-La Carlota. It will be noted that even native cane in this locality differs widely from that in other parts of the islands. So far as I have been able to ascertain, none of these five varieties has been tried elsewhere in Negros, although during the past year a few plants were set out by some of the planters in the lower lands of the same district, more as a curiosity than anything else. Number 8 is said to be a wild, mountain variety, somewhat darker in color but otherwise differing only in a few minor points from the ordinary purple cane. Analysis shows it to be of very good quality, although a little hard and high in fiber.

Numbers 9 and 11 are said to be the third ratoons from Hawaiian Rose Bamboo. They are of much better quality than the original plant, and illustrate the tendency of canes growing in an exceptionally fertile soil to become sweeter, although often smaller, after several years of ratooning.

Number 27 comes from a small field of very rich virgin soil, previously mentioned as number 21, of the district of Bago. Although it has ratooned one year, it yields a juice so poor that only by mixing it in the mill with other better canes could a fairly good sugar be produced. The manager of the hacienda where this was grown states that from the first planting no sugar at all could be made, only molasses. Such soils as this which are considered too fertile for sugar cane, are occasionally met with in Negros, and it is customary to "chastise" them by planting closer together, allowing the cane to ratoon without turning over the land, dispensing with all cultural operations so as to permit of a good growth of weeds, and in general acting contrary to all rules of agriculture, with the idea that in time the over luxuriant growth will become discouraged and yield a smaller, sweeter crop.

Theoretically, the remedy should lie in just the opposite course—by planting farther apart, the cane roots would have an opportunity to spread out and form a firmer support for a large cane, and, more space being allowed for the penetration of air and sunlight, more favorable conditions for ripening would be afforded. The principal reason that very fertile soils in this country often produce a poor quality of cane would appear to be that, especially in the case of the purple native variety, which is normally low in fiber, the roots at the start are not sufficiently developed to support a heavy stalk, which, as a consequence, falls over on the ground, where it forms a tangled mass of vegetation into which light and air can not very well penetrate, the result being that the cane never has a chance to become fully ripe.

Number 30 is a white cane similar to that grown extensively in Luzon. It is not liked in Negros, as it is said to be harder and to yield a juice less rich than the purple, therefore it is never planted intentionally, but is only to be found here and there in isolated stools.

Number 40 is a "freak" cane said to occur only in the San Carlos district, where it is considered by some to be a natural hybrid between the true sugar cane and a coarse species of wild grass called locally "tigbau" (*Saccharum*

spontaneum Linn.). The cane itself, known as "sagao," grows very tall, slender, and erect, with long joints, and is very hardy, resisting drought especially well, but is so extremely hard that it can not be ground for fear of breaking the mill. Analysis shows it to be of very little value as a source of sugar.

Numbers 41 and 47 are ratoons from cane somewhat similar in appearance to the black Java variety, which is grown to a limited extent on some haciendas in San Carlos. It is considered a fairly good cane, although not liked as well as the purple variety because of being somewhat harder to grind. In composition it is a little lower in sucrose and decidedly higher in fiber than the latter, and consequently has a greater tendency toward an erect growth. It should prove of value for planting in sandy and over-rich soils, where the purple variety sometimes falls down badly and deteriorates in quality.

CANE IN THE HAWAIIAN ISLANDS.

Geerligs [13] gives Hawaii credit for producing a sweeter and purer cane than almost any other country in the world, only that of Peru being able to rival it. Among the different factories there, the highest monthly averages of sucrose in the cane ground were, during the campaign of 1909, 16.01, 15.89, 15.87, and 15.85 per cent in the cane, these figures applying to Lahaina cane grown in the dry regions under irrigation. The cane was planted in June, 1907, it tasseled in November, 1908, and was grown from March to May, 1909; so that it had been in the ground, on an average, twenty-two months before cutting. However, ratoons a year old, grown under natural rainfall, had by no means so high a sugar content. The fiber in Hawaiian cane is stated to be on an average about 12.5 per cent, with a maximum of 15 and a minimum of 10 per cent. In comparison, our Negros cane is on the whole fully as rich in sucrose as that from Hawaii, and in addition contains decidedly less fiber, so that, under the same process of manufacture, it should allow of even a higher extraction. However, it must be admitted that these data are not absolutely comparable, since those from Negros are based on clean, stripped cane, although not selected, while the Hawaiian figures refer to what was actually ground in the factories, including the small amount of dirt and trash inevitably weighed as cane. Experience has shown that, in Negros at least, cane delivered at the mill contains from 1 to 3 per cent of trash, which would increase the figures of its fiber content when ground in the mill by an approximately similar amount, at the same time decreasing its percentage of sugar 0.2 to 0.5 per cent. Because of the greater care taken in handling the cane in the Hawaiian Islands, the difference there is probably by no means as great.

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[13] *Loc. cit.*

EGYPTIAN CANE.

Tiemann[14] says that in Egypt, in a good and frost-free year, an average campaign content of 14 per cent of saccharose on the weight of the cane can be reckoned upon, whereas in stormy years, when the cane is laid low and frost puts in its appearance, farmers can only count on 12 per cent. He gives an analysis made in March, 1897, an exceptionally good year, of a field planted the year before:

Brix	19.2
Per cent sugar in juice	16.88
Quotient	87.9
Per cent sugar in cane	14.5
Per cent glucose	0.18

Average length of canes, 6 feet.
Average weight of canes, 1.19 kilos.
Average weight of leaves, 0.27 kilo.

These especially good canes in Egypt would be considered to be of only fair quality by the average planter of Negros, and only fit for making "No. 3" or "No. 2" sugar at the best.

JAVA CANE.

Geerligs[15] states that the average cane ground in 107 factories in Java in 1908 contained 12.30 per cent sucrose and 12.01 per cent fiber, on the weight of the cane, the average purity of the raw cane juice being 83.74. This could only be expected to produce "No. 3" sugar or worse in Negros.

LOUISIANA CANE.

Stubbs[16] quotes the results for the ten years ending 1897 at the Belle Alliance factory as follows:

Tons cane per acre	23.39
Metric tons cane per hectare	58.73
Juice composition:	
Brix	15.00
Sucrose	11.78
Glucose	1.56
Purity	78.53

Under the present conditions of manufacture in Negros, such cane as this would hardly pay for the grinding, as it would only yield a very poor grade of "corriente" sugar—that is, one polarizing about 70.

[14] *Loc. cit.*

[15] Statistics of the Factory Results on a Number of Java Sugar Estates, *Int. Sugar Journ.* (1909), 11, 324.

[16] *Louisiana Agr. Exp. Sta.* (1902), *Bull.* No. 70.

WEST INDIAN CANE.

Watts[17] states the composition of the cane ground at the central factory at Antigua, British West Indies, during the year 1907 to be as follows:

	Per cent.
Cane:	
Sucrose	14.39
Fiber	15.07
First mill juice:	
Brix	20.58
Sucrose	18.51
Purity	89.09
Glucose	0.93
"Whole" juice:	
Brix	20.58
Sucrose	17.06
Purity	87.03
Glucose	0.88

This cane, although comparable with that of Negros in point of richness and purity of juice, would hardly be appreciated here because of the large amount of fiber which it carries.

NEGROS AS COMPARED WITH OTHER COUNTRIES IN RESPECT TO THE QUALITY OF CANE.

The foregoing comparative analyses establish rather conclusively the fact that, contrary to what is perhaps the general impression, based on the idea that "nothing good can come from the Philippines," the native cane ordinarily grown in Negros is, in respect to the richness and purity of its juice, equal to that of almost any other sugar-producing country in the world, and, having in addition a comparatively low fiber content, could hardly be improved upon in its adaptability to a thorough and economical extraction by milling. It would almost seem that there had been evolved here by an unconscious process of selection the type of cane most nearly suited to a country where mills are, as a rule, weak and inefficient, and where the quality of sugar produced depends almost entirely upon the original purity and concentration of the cane juice.

DESIRABILITY OF INTRODUCING OTHER VARIETIES OF CANE.

However, the fact that we are already the fortunate possessors of such a good quality of cane should not deter us from attempting to improve upon it. The sugar content of a cane is, as often as not, a function of soil and of climatic conditions rather than an inherent quality peculiar to a certain variety, and it is quite possible that other kinds of cane might be introduced here which would combine the good

[17] *West Indian Bull.* (1908), **9**, 91.

qualities of the varieties already present with a large size and greater yield per hectare. Furthermore, even if the native variety should still prove best for general cultivation, it is very advisable that each hacienda should have one or two other kinds available for planting in case of need, since costly experience in other countries has proved that where one variety of cane has been grown for a long time, to the exclusion of all others, it may suddenly succumb to the attacks of diseases, which, doing little damage at the start, after existing for many generations under exactly the same conditions, become much more virulent and parasitic in character toward the particular variety of cane which they have been attacking.

Such a condition of affairs, as shown by Tempany[18] in the case of a certain variety growing in the West Indies, is more liable to occur with a soft and juicy cane than with one containing a larger amount of fiber. It may best be held in check by the temporary substitution of other varieties of more resistant cane.

THE CULTIVATION OF SUGAR CANE AND THE PRODUCTION OF SUGAR AS CARRIED ON AT THE PRESENT TIME IN NEGROS.

PREPARATION OF THE SOIL.

It is practically the universal custom in Negros to burn the cane fields immediately after removing the season's crop of cane, or as soon thereafter as weather conditions will permit, thus ridding the land of trash and leaving the ground in a fit condition for plowing without delay. This practice is of further value in that injurious insects which might otherwise breed in the decaying leaves and stubble are in a large measure destroyed, and the potash and phosphoric acid contained in the trash are made more readily available to the coming crop. It has the disadvantage, however, that practically all the nitrogen content of this vegetable matter is lost during the burning process, and a soil already comparatively poor in nitrogen is still more impoverished each year. However, results on the whole seem to justify burning the trash, as Philippine cane in general is remarkably free from disease and from insect pests.

Shortly after removing a crop of cane and burning a field—as a rule, between the months of November and April—if it is to be replanted for the coming season, the ground is first given a preliminary plowing, termed in Visayan "lusoc," each field being plowed from two to six times before it is considered in fit condition for planting. If the field to be planted is one that has lain fallow from the previous year, this preliminary tillage of the soil may begin as early as July or August in order to have everything in readiness by the time the planting season begins.

[18] The Passing of the Bourbon Cane in Antigua. *West Indian Bull.* (1909), 10, 34–54.

The old-style native wooden plow drawn by the carabao is still largely in the majority, and, although American plows are coming into more general use each year, it will probably be a long time before the native implement is entirely supplanted, as the latter has the advantage of cheapness and simplicity, and owing to its light draft (the ground is penetrated to a depth of only about 10 centimeters) is considered to be easier on the carabao. It is generally estimated that ten men, ten plows, and twenty carabaos can, for the first plowing, take care of a little over one hectare of land per day, depending of course very largely on the nature of the ground and the condition of the weather. Subsequent plowings require considerably less labor.

After the ground has been gone over from two to five times with the plow, followed in most cases by a harrow, it is laid out in rows preliminary to receiving the seed. These rows are about 15 centimeters deep and may be from 75 to 150 centimeters apart, according to the system of planting employed.

PREPARATION OF THE SEED.

Only the white tops of the cane are used for seed. These are either cut off while the cane is still standing in the field, or the cane may be cut down first and the tops removed later.

In either case they are cut before transporting the cane to the mill and piled in heaps on the ground, after which the uppermost portion of the green stalk and leaves are cut off with a bolo, leaving for planting a section of the cane top from 20 to 25 centimeters in length. These tops, or "puntas," as they are now termed, are, as a rule, loaded into carabao carts and taken to some convenient spot, where they are stored temporarily in a shed or under a roof of some kind to protect them from the sun.

During the early part of the planting season, and when the ground is sufficiently moist, the cane seeds are planted as soon as possible after cutting, without any preparation except husking, but in very dry weather it is customary to soak them in water for from one to three days before setting them out, thus hastening the sprouting it is believed, and rendering the seed more resistant to drought. Any convenient stream or ditch may be used for this preliminary soaking, but some haciendas have tanks or troughs especially constructed for the purpose. When it is considered that the "puntas" are ready for planting, they are taken from the water and stripped of the outer layer of dead leaves still adhering to them, then carted off to the fields for planting. Most of the work of preparing the cane seed is done by women and children, who are paid by contract so much per "lacsa" of 10,000 tops.

PLANTING.

There are several different methods of planting in vogue in Negros, the most usual one, probably, being to plant in rows about 1 meter apart and to leave a space of about 40 centimeters from point to point between the seeds in the same row, thus using very nearly 25,000 seeds per hectare. Whatever the system of planting, it remains fairly constant for each

locality, so that the "lacsa"[19] is often used as a unit for land measure, meaning in this case the area in which 10,000 cane seeds have been planted or might have been planted, and varying according to locality from one-third to one-half of a hectare.

The cane tops are thrust into the ground in a slanting direction at the bottom of the furrows, then packed around with loose dirt so that only a few centimeters project above the surface. This work is, as a rule, performed by men, each man having a boy assistant, who hands him seed from a basket as it is needed. In a few localities women and children plant as well as prepare the seed. Sometimes, more especially in dry years and toward the end of the season, tops are planted in pairs instead of singly, with the idea that if one fails to sprout the other will in all probability succeed. In using this method the distance between rows and between seed in the same row is correspondingly increased, so that very rarely will the number of plants in a hectare exceed 30,000. On the east coast of Negros, where drought is sometimes to be feared, cane is often planted by means of the "gajo" or "vara," a sharpened stick frequently provided with a sharp-pointed iron cap, which is thrust into the ground in a slanting direction to a depth of some 40 centimeters, forming a hole into which the seed cane is pushed, after withdrawing the planting instrument. The advantage claimed for this method of planting is that the seed is buried deeper in the ground and consequently withstands dry weather better than when planted by other methods, so that sprouting is surer, and although the young sprout is somewhat later in making its appearance above ground, its root system has by this time become so well developed that a strong growth is ensured. In the district of Bais, especially, this system of planting is much used. There the cane is often planted in squares instead of in running rows. Two canes are set at each of the four corners of a square in such a way that a space of about 1 meter is left between each pair of cane seeds; thus approximately 2,000 seeds are planted in each hectare of land. Cane planted in this way, it is stated, can be kept free from weeds by cross plowing without danger of injuring the young plants, whereas the system of planting in rows permits of subsequent plowing in one direction only, and the cane rows themselves must be kept clean, at considerable expense, with the hoe. On the other hand is the disadvantage, at least with plant cane, that planting in squares probably produces a lesser number of individual canes to the hectare, and, leaving a greater area of land unoccupied, incurs more expense for plowing, since not only is there more space to be kept free from weeds, but a longer time must elapse before the field of cane "closes up" and by its own shade prevents further weed growth. It would appear that planting in rows probably yields a heavier first crop, but that where several years of ratoons are desired the square system might be given the preference, as subsequent ratoons thus have more room to spread without choking up the rows and making plowing between the young cane impossible.

CULTURAL OPERATIONS AFTER PLANTING.

The amount of labor expended on the young cane during its growth depends of course very much upon local conditions as to weather, soil, etc., and upon the resources of the individual planter. The following notes apply more especially to the methods followed in the district

[19] A native word meaning "ten thousand."

around Pontevedra and La Carlota but may be taken as fairly representative of the system employed throughout the whole Island.

Four or five weeks after planting, when the young sprouts are 30 to 40 centimeters high, the first plowing, called "pahulug," is made. This consists in plowing two furrows close along the cane in each row, so that the dirt is thrown away from the cane and toward the center of the row. If the plowing is simply to kill weeds, and dirt is neither taken away from or thrown up on the cane, it is called "tudling." Then, with a hoe, any weeds or dirt thrown up by the plow are cleaned off from around the cane. In districts where cane is planted in squares, "pahulug" is made by plowing two furrows between the cane in each direction, without the use of the hoe. Fifteen or twenty days later, if weeds have sprung up again, the operation of "pahulug" must be repeated. After this, no further labor is required except an occasional plowing or harrowing to keep down weeds until the month of May or June, or until the first rains begin and the operation known as "pasandig" is necessary.

Three furrows are plowed between each row, throwing the dirt up around the roots of the cane and making a shallow trench in the center between rows. This treatment, just the opposite to "pahulug," is to prevent water from standing around the roots of the young cane and injuring its growth. If, as sometimes happens, a considerable period of dry weather intervenes after the first rains, it may be necessary to repeat the "pahulug" once more, but as soon as the rainy season really sets in, generally in July, dirt is again thrown up around the roots of the cane, which should by this time have attained a height of about 2 meters. This final labor, called by the natives "pasaca," is similar to "pasandig," but four furrows are made between the cane rows instead of three, dirt is packed higher up around the cane, and a much deeper trench is left in the center. Sometimes a finishing touch is given by performing the labor called "lambon," which consists in banking up earth along the sides and ends of the rows with a shovel, and leveling off uneven spaces between the cane so as to leave no opportunity for water to collect around it. Such a practice is considered to be more ornamental than absolutely essential. The field is now considered "cerrado," closed up—that is, the cane has reached a sufficient height and strength of growth so that its own shade prevents the further growth of weeds—and it can be left alone until harvesting time.

CULTIVATION OF RATOON CANES.

The foregoing description applies to the cultivation of plant cane only. A decidedly large proportion of the total land under cultivation in Negros, however, is not replanted every year, but is allowed to ratoon, from two to eight crops being taken off without replanting. This is especially true in the rich soils of the districts around Ilog-Cabancalan, Binalbagan-Isabela, San Carlos, and Bais. Theoretically, cane planted in some of these alluvial soils, which are flooded and fertilized each year by silt brought down from the mountains by the overflow of a river, might go on ratooning indefinitely. Practically, the period between plantings is limited strictly by financial considerations.

Much time and expense are saved by not being obliged to replant. On the other hand, the yield from plant cane is as a rule greater than

even from first ratoons, and with each successive ratoon crop the total amount of sugar produced per hectare of land is decidedly diminished. This is partially due to the shorter time in which the cane is allowed to ripen. Owing to excessive rains prevalent in this country, cane must be cut every year, and the practice so common in Hawaii of allowing ratoons to ripen for eighteen months or more is here out of the question. A further obstacle, especially when canes are planted closely in rows, is the tendency of ratoons to spread out in every direction from the original plant, so that in the course of a few years the cane rows lose all semblance of regularity and proper tillage of the soil is rendered very difficult; thus many young ratoons are stunted in their growth by weeds.

From data which I have been able to gather on this subject, the yield of sugar, as made by the customary native process, from 1 hectare of good cane land in the more fertile districts may be estimated approximately as follows:

Plant cane, 100 piculs (of 63.25 kilos) or 6.33 metric tons; first ratoons, 80 piculs or 5.06 metric tons; second ratoons, 70 piculs or 4.43 metric tons; third ratoons, 60 piculs or 3.80 metric tons; fourth ratoons, 50 piculs or 3.16 metric tons. Cane which yields less than 2 metric tons of sugar to the hectare is here considered hardly to be worth the cutting. The length of time during which it is profitable to let cane ratoon also depends largely on the cost of labor and the total area of land available for cultivation. On a small plantation, if labor is cheap, it is considered good policy to replant nearly every year in order to get the utmost possible yield. With plenty of land at his disposal, especially in districts where labor and animals are scarce, the hacendero has better results by letting his cane ratoon as long as it pays to cut it. The average time between replanting in the districts where canes are generally allowed to ratoon may be taken as four years, so that of the total sugar produced in these districts about one-fourth will be from plant cane and three-fourths from ratoons.

For the cultivation of ratoon cane or "kalaanang," as it is universally called here, it is customary as soon as possible after removal of the crop and burning the field to plow the "pahulug" and then with a hoe to take away the dirt from around the old plant, leaving its roots exposed to the air and the sun. The field is left alone for from four to six weeks to allow the outermost of the old roots to decay, being plowed or hoed just enough to keep down weeds, then another plowing throws dirt up around the young cane sprouts, and from this time on the treatment is much the same as for plant cane.

PERIOD OF GROWTH OF THE CANE.

The length of time during which the cane is allowed to remain in the ground varies from nine to fourteen months and will probably average between eleven and twelve. As each plantation grinds its own

cane, the exigencies of milling largely determine the time of cutting, and therefore the time of planting. Naturally, where the same fields are cultivated year after year without rest or change of crops, the average period of growth of the cane must be somewhat less than twelve months. If fields are planted only on alternate years this period may be somewhat lengthened. Sometimes an exceptionally long rainy season delays grinding for one or two months and correspondingly shortens the growth of next year's crop. When clear weather does come, every energy is expended to keep the mill running full force and properly supplied with cane, so that fields are often cut before they are fully ripe, much to the detriment of the sugar produced. Again, especially toward the end of the season, a prolonged dry period may occur, during which cane which happened to be planted late on the previous season and which had not yet attained maturity begins to succumb to the heat and must be cut down at once to avoid a total loss. I have seen fields of large cane of fine appearance, less than ten months old, which needed to be sacrificed in this manner, in part too green to produce good sugar and in part dead from heat and lack of moisture. This condition is, of course, not so likely to occur on the heavy clay soils as on the sandy or alluvial ones.

COST OF CULTIVATION.

This is a subject which has been so thoroughly and so energetically discussed during the past few years, and one concerning which it is possible to obtain such widely varying estimates, according to the point of view, that the seeker after truth enters upon it with considerable trepidation. Especially when calculated to the picul, pound, or ton of sugar produced does this cost of field operations show its widest variation, since, as has been shown previously, the yield in sugar from 1 hectare of land may be anywhere from 20 to 200 piculs (1.26 to 12.6 metric tons), according to the soil, climatic conditions, care and intelligence in cultivation and in manufacture, and many other equally important factors, whereas the actual labor expended on the land will vary within somewhat narrower limits. Still, it will generally be found that the greater the cost of cultivation per hectare of land the more sugar will be produced from it. In a few haciendas where the field labor is paid for by contract, the price for plowing, cutting seed, planting the cane, and keeping it free from weeds until ready to harvest is from 50 centavos to 2 pesos for each picul of sugar produced, averaging, as a rule, about 1 peso (15.80 pesos per metric ton), all work animals, plows, carts, etc., being furnished by the hacienda.

The following estimate, based upon the number of men required to perform the previously described field operations and the cost of labor

at 40 centavos per day, may give some idea of the approximate cost of cultivating 1 hectare of land. In estimating these costs an endeavor has been made to approximate what is customarily paid throughout Negros, rather than to give figures representing extremely economical, successful management, or the reverse. The data on which they are based were nearly all secured at first hand from the planters themselves, and as some of them comprise confidential information concerning particular haciendas, it has been deemed best to omit altogether any statement of the sources from which my information was derived.

Estimate of the approximate cost of plowing, planting, and caring for 1 hectare of land already under cultivation from the time the field is burned until the cane is ready for cutting, based on the cost of labor at the rate of 40 centavos per day, no charge being made for work animals, implements, or supervision.

Nature of work performed.	Number of carabao-days required.	Number of man-days required.	Cost in Philippine currency.
			Pesos.
Preliminary cleaning off of trash from the field		4	1.60
First plowing	18	9	3.60
Second plowing	12	6	2.40
Third plowing	8	4	1.60
Two harrowings between plowings	6	3	1.20
Fourth plowing, including preparation of furrows for planting	8	6	2.40
Cutting 30,000 cane tops for seed		10	4.00
Hauling seed to canal or deposit	3	3	1.20
Husking seed		4	1.60
Hauling seed to field	3	3	1.20
Planting 30,000 seed		10	4.00
First weeding (with hoe)		12	4.80
Replanting of 5 per cent of seed which failed to sprout		2	0.80
"Pahulug" (two furrows between rows)	8	4	1.60
Second weeding (with hoe)		12	4.80
"Pasandig" (three furrows between rows)	10	5	2.00
"Pahulug" (two furrows between rows)	8	4	1.60
Third weeding (with hoe)		10	4.00
"Pasaca" (final plowing of four furrows between rows)	12	6	2.40
Total	96	117	46.80

The above refers to the cost of plant cane only. Although no accurate data are available on the subject, it is a safe estimate that fully one-half of all the sugar produced in Negros comes from the so-called "kalaanang" or ratoons. If a field is allowed to grow for a second year without replanting, the cost of caring for it is, of course, diminished by the amount ordinarily spent on the preliminary plowing, cutting of seed, and planting. The cost of cultivating a ratoon crop would then be about as follows:

Estimate of the approximate cost of caring for 1 hectare of land already planted and allowed to ratoon without replanting from the time the first crop has been taken off and the field burned until the second crop is ready for cutting, based on the cost of labor at 40 centavos per day, no charge being made for work animals, implements, or supervision.

Nature of work performed.	Number of carabao-days required.	Number of man-days required.	Cost in Philippine currency.
			Pesos.
Preliminary cleaning of field		4	1.60
"Pahulug" (two furrows between rows)	10	5	2.00
"Pacad" (cleaning dirt away from roots of old plant with hoe)		14	5.60
"Tudling" (straight plowing to kill weeds)	8	4	1.60
First weeding (with hoe)		10	4.00
"Pasandig" (three furrows between rows)	10	5	2.00
"Pahulug" (two furrows between rows)	8	4	1.60
Second weeding (with hoe)		10	4.00
"Pasaca" (final plowing of four furrows, banking up rows)	12	6	2.40
Total	48	62	24.80

Thus, it will be seen that on the average for a fairly well equipped and managed plantation in Negros, growing half plant cane and half ratoons, there will be required for each hectare of land in cultivation the services of one carabao for 72 days and of one laborer for 89.5 days, at a cost for the latter of 35.80 pesos. The period of time over which these cultural operations extend, from the burning of the first field to the closing of the last, may be placed at approximately seven months of 25 working days each, or a total in each year of 175 working days, and for purpose of calculation it can be stated that 1 hectare of land requires for its cultivation $\frac{72}{175}$ or 0.441 "carabao-year," if the term may be admitted, and $\frac{89.5}{175}$ or 0.511 "man-year," the value of a man-year for field work being put at 70 pesos. If carabaos are not owned by the hacienda, but rented, or charged for as rented, at the rate of 50 centavos per day, a carabao-year would be worth 87.50 pesos, and the expense charged to cultivation would be almost exactly doubled. Perhaps the better way of calculating, however, is to charge for the bare cost in wages of men and figure in the work animals later together with the cost of implements and general equipment.

Land cultivated in the previously described manner may be expected to yield from 40 to 80 piculs (2.53 to 5.06 metric tons) of raw sugar per hectare and will average, between plant cane and "kalaanang," fully 60 piculs (3.79 metric tons), so that the average amount paid out in wages and maintenance of laborers for field work in cultivating and caring for the cane, when reduced to the unit basis of sugar produced, comes to 60 centavos per picul, or 9.49 pesos per metric ton.

This figure will undoubtedly be considered too high by some growers and too low by others, depending largely on the amount of ratoon cane they raise, but it approximates very closely the average cost throughout Negros. It may be objected, with some degree of truth, that the average production of Negros is not

60 piculs per hectare, but only 42.9 piculs. It will also be found true that those haciendas which produce much less than 60 piculs per hectare spend proportionally less in caring for their cane, so that the cost per unit of sugar raised thus tends to equalize itself.

Since each hectare of land planted in sugar cane under the previously stated conditions requires 0.441 carabao-year and 0.511 man-year for its proper cultivation, the approximate number of animals and laborers needed for field work on a hacienda of a given size can readily be determined; thus on an average-sized plantation of, say, 150 hectares of cultivable land, 50 hectares of which are in plant cane, 50 in ratoons, and the remaining 50 uncultivated, there will be necessary some 44 carabaos and 51 laborers for field work in caring for the cane before it is harvested. All this refers to cultivation by the methods now in vogue. An American planter in Negros states, however, that by the use of disc plows for all operations except that of marking off cane rows for planting, and by a more liberal use of the harrow, he has succeeded in materially reducing the cost in animals and men required to take care of a field, and, at the same time, keeps his land in better condition than under the old methods. A few of the larger haciendas are equipped with steam plows, nearly all being of the direct traction type. These, in light soils and in dry weather, are said to do the same amount of work much more satisfactorily and at a less cost than is possible by means of carabaos, although they labor under the disadvantage of not being able to work well in wet or heavy clay. Quite recently a few sets of cable plows have been introduced, which have to a large extent overcome this latter difficulty and should prove a valuable acquisition to those who can afford them.

CUTTING THE CANE.

If cane tops are in immediate demand for seed, a whole field may be topped at once and then cut later as needed for grinding. If cut within two or three days after topping, there is said to be very little deterioration in the juice. Sometimes, during a temporary stoppage of the mill, enough cane is cut for several days' supply, a practice which at times leads to serious losses when, for instance, because of wet weather or some slight accident to the mill, grinding is delayed longer than was intended. I once saw a mill which was crushing some very good looking cane, but was turning out a sugar of 68.6 polarization and 17.4 glucose.

Juice from the mill was analyzed as follows: Brix, 20.86; sucrose, 16.18; purity, 77.6; glucose, 2.76. I was informed that this cane had been topped ten days previously, and owing to a breakdown in the mill had lain for five days after cutting before being ground! Twenty canes were taken at random from the lot, sections of about 20 centimeters in length cut from top and bottom of each, and the juice from tops, middles, and bottoms analyzed separately, with the following results:

	Tops.	Bottoms.	Middles.
Brix	21.40	23.60	21.72
Sucrose	15.81	18.88	17.34
Purity	73.89	79.98	79.84
Reducing sugar	3.51	2.81	2.75
Reducing sugar per 100 polarization	22.2	14.9	15.9

Although the whole cane shows a decided deterioration, the tops have evidently suffered more than the rest. This fact is well known to most planters, who generally cut off a small portion from the top of the cane if it has been stored more than a few days before grinding. In some haciendas it is customary to cut down the cane before removing the top, or, again, the two operations may go on simultaneously, one gang of men cutting tops and another following them cutting and carrying out the cane. All this work is done with the ordinary, blunt-ended native working bolo, locally termed "binangon." The native laborer in this, as in other work, follows the line of least resistance, and unless closely watched he is apt to find it easier to cut off the cane a goodly distance above ground rather than waste time and energy in cutting it level with the surface. It is not uncommon to see a field of stubble averaging 10 centimeters in height, which means a loss of some 5 per cent of total sugar right at the start.

A few haciendas in the district of Isabela make a practice of burning a field before commencing to cut cane. The plantation is divided up by roads into fields sufficiently large to supply the mill for two or three days, and each field is burned separately just before cutting. Nighttime is, as a rule, chosen, as there is not likely be a strong breeze, the field being fired against the wind, with a guard of men stationed to prevent the spreading of fire to an adjacent field. It is claimed that practically no loss of sugar results from burning provided the cane is ground without delay.[20] When properly controlled, much time and labor is undoubtedly saved by this procedure, as all trash is removed at the start, leaving only the bare cane stalks to be handled. This is rather dirty work, but is easier on the men, and the cane comes to the mill clean and free from trash, which is another decided advantage.

TRANSPORTING THE CANE TO THE MILL.

Methods of transporting cane from the fields to the mill are numerous and varied. The larger, better-managed haciendas are fairly well equipped with light portable tramways, mostly of English, German, or Belgian make. The rails are quite light, running from 10 to 14 pounds per yard (approximately 5 to 7 kilos per meter), and, as the track is put up in short sections, it can be moved about easily from place to place in the fields, as needed. In some plantations a main line of semiportable track is used, and branches are run from this into the fields as feeders. Skeleton cane cars of iron with wooden bottoms form the rolling stock; they hold about 1 ton of cane, and are most economically drawn by Chinese bullocks, less frequently by carabaos. The carabao, although stronger, is slower and less adapted to this class of work. In some districts where work animals are scarce, men

[20] Geerligs [Cane Sugar and Its Manufacture, Manchester (1909) 72] corroborates this statement *as far as the immediate effect of fire is concerned*, by analytical data. However, on standing more than two or three days after being burned, a very rapid deterioration sets in.

are employed to push the cane cars. The gravity system is also used to some extent where the mill can be located on a lower level than the cane fields. The cars come down full of cane, controlled and helped over the level places by one man to each car, and are drawn back to the fields empty, in trains of five to ten, by work animals. Where tramways are not available and for long hauls, light four-wheeled wagons having a capacity of about 2 tons of cane, drawn by two animals, are often employed. The primitive two-wheeled carabao cart is also much in evidence. On one hacienda a steam traction engine is at times pressed into the service and made to pull three or four wagonloads of cane in a train. All the work of loading and unloading cane is done by hand, the cane loader not yet having made its appearance in this country.

COST OF CUTTING THE CANE AND TRANSPORTING IT TO THE MILL.

The cost of cutting cane when paid for by contract ranges from 12.5 to 20 centavos per picul (1.98 pesos to 3.16 pesos per metric ton) of sugar produced, according to the size and quality of the cane, the value of labor in the vicinity, and the planter's reputation for requiring careful and thorough cutting.

One man can, on the average, cut cane equivalent to about 2½ piculs of sugar during the course of a day, which taking the average wage as 40 centavos, makes the amount paid for cutting about 16 centavos a picul (2.53 pesos a metric ton) of sugar, a figure not far from that paid by the average planter. Transportation costs are subject to somewhat greater variation, the lowest estimate I have heard quoted being 10 centavos per picul (1.58 pesos per metric ton) of sugar produced and the highest 25 centavos per picul (3.95 pesos per metric ton), the difference being occasioned by the greater or less distance of the fields from the mill and the facilities for transportation available. At these prices carts or wagons and work animals are supposed to be furnished by the hacienda. If done by day labor, about the same number of men will be required to load and unload cane carts and handle the animals as are needed to cut the cane, so that the average amount paid out for transportation of cane will likewise come to about 16 centavos per picul or 2.53 pesos per metric ton. In addition there will be needed from eight to twelve oxen ("vacas") and a corresponding number of cane carts for each 100 piculs (15.8 metric tons) of sugar made per day.

MANUFACTURE OF SUGAR FROM THE CANE.

EXTRACTION OF THE JUICE.

Mills.—The sugar mills of Negros may be divided into three classes—first, those driven by steam; second, those run by water power; and, third, those using carabaos or oxen as a motive power. Of these, the steam mills greatly predominate; the carabao mills, or so-called "molinos de sangre," are so rapidly disappearing that, in the course of six months spent in the more important sugar districts, I was only able to see three of them in actual operation; while the water-power mills are

nearly all confined to small haciendas in the interior of the districts of Bago and La Carlota (La Castellana), where small mountain streams afford power enough to grind from 30 to 60 tons of cane per day.

The steam mills are practically all of English or Scotch origin, of the ordinary 3-roller type, driven by direct-gear connection with a single-cylinder engine running at from 40 to 80 pounds' steam pressure, and rated at a nominal horsepower of from 6 to 16, the average throughout the island being about 8 to 10. It is calculated roughly that each horsepower possessed by an engine is capable of grinding sufficient cane in an ordinary working day of twelve to fourteen hours to make 10 piculs (632.5 kilos) of sugar, so that the average mill of Negros may be said to have a daily capacity of from 80 to 100 piculs (5.1 to 6.3 metric tons) of sugar, or approximately 50 to 60 tons of cane.

Feed.—The cane, as it comes from the field in carts or cars, is dumped in the ground near the mill, and then fed into it by hand, an armful at a time. Some mills are provided with mechanical carriers which permit of a rather more even feed and are somewhat easier on the men, as the cane can be fed directly from the ground instead of being carried by hand up to the elevated platform on which the mill stands. As considerable care is required in laying the cane on the carrier evenly and in its manipulation, very little time or labor appears to be saved by this device, and the total number of laborers needed is about the same in each case.

Fuel.—In clear weather, with a properly constructed mill and boiler, the bagasse produced is generally sufficient to supply all the fuel needed, both for grinding and sugar boiling, with some left over for a rainy day. As the bagasse comes out from the mill it is supposed to be picked over by a couple of men stationed there for that purpose, and any unbroken or imperfectly crushed pieces thrown back to be ground over, the thoroughness with which this inspection is made depending largely upon the proximity of the owner or manager of the plantation. As the fresh bagasse contains about 55 per cent of water, it can not be burned directly under the boilers, but must first be dried in the sun, so it is carried out for this purpose in baskets or cradles of bejuco (rattan) slung from bamboo poles, to the plaza, a level space about a hectare in extent surrounding the mill house, and there spread out on the ground and raked over from time to time so as to dry rapidly. At night it is raked up into small piles, then spread out again for a few hours the next morning, when it is usually sufficiently dry either to burn at once or to store in the bagasse sheds for future use. One of the most serious problems the hacendero has to solve is that of always keeping on hand a sufficient supply of dry bagasse to run his mill. In rainy weather this is almost impossible; the surplus stored up in the sheds becomes exhausted in a couple of weeks, and he is compelled either to shut down entirely or to burn wood at a heavy expense; in the meantime the fresh bagasse produced can not be properly dried; and if stored wet it ferments and loses much of its fuel value in consequence.

It is principally for this reason that the planter of the Philippine Islands is so badly hampered by climatic conditions; his field work of planting and harvesting, both carried on at the same time, is largely influenced by the rate at which cane can be received at the mill, and this in turn is dependent upon an ample supply of dry bagasse, so that an unexpected season of wet weather may upset all calculations and cause much damage.

Efficiency of the mills.—In a country where cane is never weighed, and where in many haciendas the empty kerosene case is still the popular unit of volume, it is not surprising that very little is really known about the efficiency of the mills, or the losses in grinding. Bagasse changes in composition so rapidly by evaporation and fermentation that it is almost impossible to transport it any distance to a central laboratory and there determine by analysis its original composition and sugar content. Some reliable figures, of course, can be obtained by establishing a temporary laboratory directly on representative haciendas and making analyses of canes and bagasse on the spot, but even in this way the amount of ground which can be covered in a season is limited. The only really practicable means of determining mill losses accurately and at the same time with reasonable rapidity, in the case of small factories having poor transportation facilities and no chemical control, was found to be the determination of the factor "mill juice in bagasse per 100 fiber," as originally proposed by J. Lely and quoted by Watts.[21]

This factor is of great practical value in that it is independent of the water content of the bagasse, which may be completely dried if necessary and transported a long distance before analysis, when the original weight of mill juice contained per 100 parts fiber can, of course, be calculated from the per cent of fiber and of sucrose in the dried bagasse and the per cent of sucrose in a separate sample of juice from the mill. Strictly speaking, this factor is, from a theoretical point of view, not absolutely correct, a more rigid measure of efficiency of mill work being that given by Deerr[22] "as volume of juice in bagasse per unit weight of fiber in bagasse," or

$$\frac{\text{weight of juice in unit weight of bagasse}}{\text{weight of the fiber in unit weight of bagasse} \times \text{density of juice}}$$

a factor which varies only from that proposed by Lely in that it takes into account the specific gravity of the juice. Recent work has proved that, in addition, the efficiency of a mill is also influenced by the quality as well as the quantity of fiber present in the cane, so that absolutely true comparisons between mills working different varieties of cane are hardly possible. The ultimate criterion would be "volume of juice in bagasse per *volume* of fiber in bagasse," and might be expressed by some such formula as

$$\frac{\text{weight of juice in unit weight of bagasse} \div \text{specific gravity of juice}}{\text{weight of fiber in unit weight of bagasse} \div \text{specific gravity (apparent) of fiber.}}$$

As so little is as yet known concerning the difference in physical properties between different varieties of cane, the analytical determination of such a factor would be impracticable. That canes with a hard, dense fiber do as a rule yield a bagasse containing a lower relative percentage of juice than do those possessing a soft, spongy structure is a fact frequently observed, and one capable of ready demonstration. With dry crushing in mills without hydraulic pressure regulators, the

[21] *West Indian Bull.* (1908), 9, 85.

[22] Sugar and the Sugar Cane. Manchester (1905), 107.

common type in Negros, this difference is probably due to the fact that, the distance between rollers being a fixed one, the actual pressure exerted upon the cane as it passes through the mill is determined largely by the hardness of the cane itself and the consequent resistance which it offers to being squeezed out in a thin layer and made to pass through a definite-sized opening. Taking an extreme case as an example, a young cane sprout might flatten out readily and pass between the rollers without having much pressure exerted upon it, while a stick of hard wood of the same size would be subjected to such a severe pressure that it might even break the mill. In a small experimental mill with semi-fixed rollers allowed only a slight "give" by means of rubber washers to the bolts which hold them in place, this varying behavior of different kinds of canes appeared to an exaggerated extent. As a matter of record, while analyzing canes from different parts of Negros, I determined in each case the factor "mill juice per 100 fiber" in the bagasse, in addition to the regular analysis, although theoretically, if this factor is a standard of efficiency for mill work, it should, in the case of the hand mill kept at the same tension, be approximately the same for all kinds of cane. In reality it showed the most extreme variations, always in the same direction; the harder, more fibrous canes tending to yield a bagasse containing a lower percentage of juice than the softer ones, although since the bagasse produced was greater in quantity for the hard canes, the total amount of juice extracted was somewhat less. The following examples indicate the behavior of canes of different fiber content when expressed in the same mill:

No.	Fiber in cane.	Analysis of cane.		Analysis of bagasse.			
		Juice extracted.	Bagasse.[a]	Fiber.	Sucrose.	"Mill juice."	"Mill juice" per 100 fiber.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	
27	8.05	72.43	27.19	29.62	7.36	65.85	222
29	8.48	72.70	26.90	31.29	9.40	63.19	201
38	9.15	71.23	27.89	32.79	12.47	59.77	182
46	9.89	70.64	28.92	34.19	10.87	56.48	165
44	10.64	70.44	28.85	36.88	9.78	55.22	150
49	11.05	68.38	31.17	35.45	10.99	55.30	156
30	11.80	68.49	30.89	38.20	9.83	56.03	147
45	12.61	67.18	32.20	39.17	9.97	50.52	129
41	14.07	67.52	31.61	44.52	8.44	43.99	99
47	14.63	65.24	34.18	42.83	7.91	43.37	101
40	15.48	65.12	33.63	46.02	7.32	48.54	105

[a] The slight difference between the sum of juice and bagasse and 100 is due to the loss of water by evaporation from bagasse while preparing it for analysis. This was taken into consideration in calculating the percentage composition of the cane as given previously, but is not essential here.

Watts[23] gives a table showing the approximate result with different kinds of mills:

Type of milling plant.	Juice per 100 fiber of bagasse.
Bad single mill	200
Fair single mill	180
Good single mill	150
Cane splitter and single mill	130
Krajewski and two 3-roller mills with maceration	70
Krajewski and three 3-roller mills with maceration	30
Krajewski and three 3-roller mills with maceration, best work	25

According to the above, the hand mill used in making analyses of Negros canes would when working very juicy and tender canes be considered about as efficient as a very poor, single 3-roller mill, whereas with canes containing 14 or 15 per cent of fiber it would be said to approximate in power the work of two 3-roller mills and crusher, without maceration. The differences obtained in actual practice among 3-roller mills are by no means so great, but there is, as will be shown later, a decided variation in the efficiency, calculated according to this factor, of the same mill when working canes of different fiber content, so that the quotient "mill juice per 100 fiber in bagasse," can not be accepted without question as an absolute standard of efficiency of mill work, regardless of the kind of cane ground. Given about the same composition of cane, it is of some value in determining the comparative efficiency of mills in the same neighborhood, and, in conjunction with complete analyses of the canes ground, affords a ready method for ascertaining the per cent of total sugar lost in bagasse by muscavado mills.

The results of a number of determinations made on different mills in Negros are here given. The usual method of procedure in taking samples and preparing them for analysis was as follows:

Samples, consisting of a few handfuls at a time of the bagasse as it came from the mill, were taken at intervals of five or ten minutes and placed to dry in a large coarse sack laid directly on top of the uncovered portion of the engine boiler. At the same time four or five samples of 5 cubic centimeters each of juice were taken directly from the mill bed and put in a liter bottle containing 0.2 gram mercuric chloride. Sampling was continued thus for three or four hours until both bottle and sack were full; the bagasse was then, as a rule, allowed to remain for a few hours longer, while field samples of soil and cane were being taken, by which time it was sufficiently dry to allow of its being transported a considerable distance back to the laboratory. On arrival at the temporary laboratory headquarters, the bagasse was either analyzed at once or spread out over the boiler there to keep dry until morning. The whole sackful was spread out on a clean floor and chopped into coarse pieces, then quartered down to a final weight of about half a kilo, which was chopped much finer and used for analysis. The work of taking the original samples at the mill was all done

[23] *West Indian Bull.* (1909), **10**, 109.

by a trained native assistant, with the idea of disturbing as little as possible the ordinary routine of mill work, this point being of considerable importance in securing representative samples, since the efficiency of a single mill depends much upon the care with which poorly crushed pieces of bagasse are thrown back to be reground, and native laborers are prone to be somewhat too attentive to duty if they imagine their work is being inspected by a foreigner.

"Mill juice per 100 fiber" in the bagasse from various mills in Negros.

No.	District and hacienda.	Horse-power of mill.	Mill juice per 100 fiber.
	PONTEVEDRA—LA CARLOTA.		
[a]1	Carmencita (first test)	12	168
2	Carmencita (second test)		155
3	Carmencita (third test)		197
4	Carmen	[b]24	142
5	Esperanza	[c]16	170
6	Najalin	[c]12	149
	BAGO.		
7	Lumañgub	[c]12	161
8	Maliñgin	[d]12	197
[e]9	Lumañgub	12	157
[f]10	Do		161
11	Santo Domingo	[g]8	163
13	San Juan del Monte	[h]6	220
	ILOG CABANCALAN.		
14	San Isidro	16	201
15	San Jose	10	193
16	Soledad	6	207
17	San Juan	16	236
18	San Luis	6	217
	SAN CARLOS.		
[i]19	San Jose	[j]12	169
20	Providencia	[k]8	151
21	Refugio	10	151
22	Fortuna	12	216
23	Valle Hermoso	10	159
	Average		178.5

[a] Complete analysis=sucrose, 8.62; fiber, 34.7; moisture, 54.4.
[b] 5-Roller mill.
[c] 3-roller mill.
[d] Built 1889 by A. W. Smith, Glasgow; rollers, 36 by 24 inches.
[e] 5 samples taken at five-minute intervals and analyzed at once. Complete analysis=sucrose, 10.51; fiber, 34.35; moisture, 55.14.
[f] 10 samples during afternoon (bagasse dried over boilers and analyzed next day).
[g] Built by Aitken, McNeil & Co., 1882.
[h] Built by A. W. Smith, 1871; rollers, 16 by 24 inches.
[i] Complete analysis=sucrose, 12.02; fiber, 33.60; moisture, 54.38.
[j] Rollers, 22 by 42 inches.
[k] Rollers, 18 by 36 inches.

The extent to which the same mill may vary at different times is shown by the first three tests. Numbers 9 and 10, taken on the same day, indicate that as long as a mill is working the same kind of cane fairly concordant results may be obtained, also that bagasse may safely be dried and preserved, at least for a short time, without changing in

composition. It was found that with bagasse dried down to a water content of 10 or 15 per cent very little trouble was caused by fermentation, even if it was kept for several days; if not so dry it deteriorates quite rapidly.

For example, number 13, from a small and rather weak mill, on first analysis yielded a factor of only 162, owing to the fact that the sample was taken late in the afternoon, had to be carried back to the laboratory in a partially dried condition, and was left thus overnight without further drying owing to a temporary shut down in the mill and no steam in the boiler. When analyzed it still contained about 35 per cent of water. As this bagasse was so evidently poorly crushed, it was necessary to make another test of the mill and analyze the bagasse immediately, with the result, as shown in the table, of 220.

The average of all the mills tested shows that 178.5 parts of mill juice are lost in bagasse for every 100 parts of fiber in the bagasse, or, since all the fiber of the cane finally goes into the bagasse, 178.5 parts of mill juice are lost in bagasse for every 100 parts of fiber in the cane, this figure corresponding to what Watts gives as the working of a "fair single mill." From these data it is easy to calculate the percentage of juice (or of sucrose) lost in crushing by the average mill in Negros.

The average composition of the cane of the island has already been stated as sucrose, 16.06 per cent; fiber, 10.02 per cent, with a juice containing sucrose, 18.40 per cent when expressed by a hand mill; therefore the make-up of the cane is, approximately, fiber, 10.02; juice, 87.28; water other than juice, 2.70—assuming the residual juice to be of the same composition as that first expressed. Since there are 178.5 parts of juice in bagasse for every 100 parts of fiber present, there would be lost, if perfectly clean cane of the above composition were ground, 17.88 parts juice from every 100 parts cane containing 10.02 parts fiber and 87.28 parts juice.

In other words, the "extraction" of juice in per cent on the cane would be 69.40 out of a possible 87.28, or the per cent of total juice (or of total sugar) loss in milling would be $\frac{17.88}{87.28}=20.48$ per cent.

It is very doubtful if as good results as this are ever secured in actual practice, for the following reason:

To bring in cane from the fields absolutely free from trash and adhering leaves requires considerable extra care and attention, which ordinary laborers can not be depended on the exert; moreover, came is much easier to carry on the shoulder if cushioned and held together by a few extra leaves, and packs more easily in the wagons without slipping out of place, so that the cane carts usually come into the factory laden with a goodly amount of dirt, dead leaves, and other trash. A careful manager will see that the greater part of this is removed before it enters the mill, but very often up to 3 per cent or more of the weight of the cane will enter the mill dry, and come out wet with juice.

Most planters do not seem to realize the loss which this practice entails, since, judged by the eye alone, a few leaves more or less are of little importance. In some lots of cane, which had been if any-

thing a little more carefully cleaned than is customary, it was found that 500 kilos of cane about to enter the mill carried with it 12.5 kilos of dry trash. Assuming that on the average 2 parts of fiber will be introduced into the mill with every 100 parts of clean cane, we can calculate the effect produced on the composition of the cane and the results obtained in milling as given above.

The cane as ground will then contain $\frac{12.02}{102}=11.79$ per cent fiber; $\frac{87.28}{102}=85.56$ per cent juice, and $\frac{2.70}{102}=2.65$ per cent water other than juice, and the loss of juice in bagasse will be $178.5\times0.1179=21.05$ per cent on the cane, leaving an extraction of 64.51 out of a possible 85.56, and a loss in per cent on the total sugar (or total juice) of $\frac{21.05}{85.56}=24.60$.

In grinding a very hard cane, such as the black variety grown to some extent in San Carlos, the losses would be greatly increased.

Sample number 41, for instance, shows on analysis, fiber, 14.07 per cent; sucrose, 15.02 per cent; and sucrose in juice, 19.18, corresponding to a juice content of 81.43 per cent. Addition of 2 per cent fiber as trash would make the cane as ground contain 15.75 per cent fiber and 79.84 per cent juice. Assuming the average mill efficiency, there would be lost per 100 parts cane $178.5\times0.1575=28.11$ parts juice, giving an extraction of only 51.73 out of a possible 79.84 per cent and a loss in per cent of total sugar of 35.22.

In round numbers, then, it may be stated that the average planter of Negros loses in bagasse about 25 per cent of the total sugar present in the cane. In extreme cases, with very soft and tender cane, this may fall as low as 20 per cent, and when grinding very fibrous cane it may rise as high as 33 per cent. The extraction of juice on the weight of the cane may range from 50 to 70 per cent, but averages about 64.5 per cent. Therefore from 100 tons of cane there are obtained 64.5 tons of juice. This is rather better than the rsults obtained in most countries where sugar is produced by primitive methods (Watts[24] states that in Barbados the crushing ranges from 53 to 60 per cent), but should be attributed not to any superior efficiency of the mill in Negros, but solely to the free-milling qualities of the cane grown here.

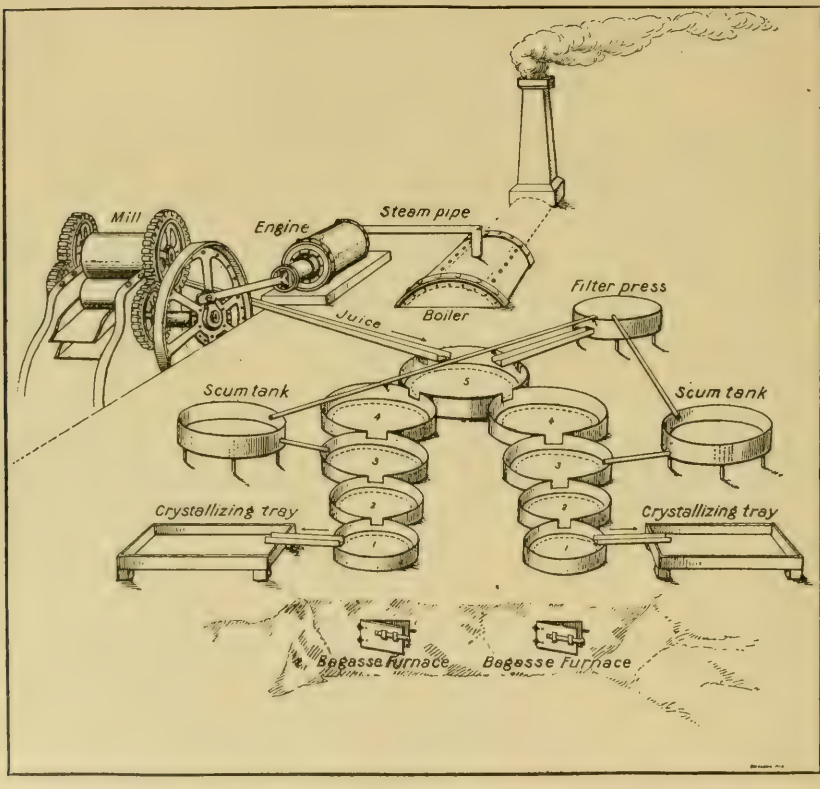
MANUFACTURE OF SUGAR FROM THE JUICE.

Arrangement of the sugar house.—The sugar-boiling plants of Negros consist essentially of a battery of hemispherical iron vessels or "cauas," uasually five or six in series, in which all the operations of tempering, clarifying, concentrating the juice, and boiling the resultant sirup to a concrete are performed.

The "cauas, which may be anywhere from 40 to 80 inches (1 to 2 meters) in internal diameter, measured from a short distance below the top, where the

[24] *Loc. cit.*

sides spread out to form a sort of lip, are built into the top of a brick or stone furnace with only their lips or rims projecting above the surface, in such a fashion that they extend in a direct line, ascending slightly in elevation from the largest, where the juice enters from the mill, to the smallest, or "caua mayor," also called "caua de puntos," in which the final operation of boiling the sirup to a "massecuite" is carried out. To prevent loss of the juice by boiling over, the whole battery is built up along the sides and inclosed by a protecting wall of brick or cement, 40 or 50 centimeters high, or an extra perpendicular rim of thin iron may be attached to the top of each "caua." The accompanying schematic diagram gives a good idea of the most customary arrangement of a sugar house.



There are really two distinct batteries built over separate furnaces, having only the No. 5, or juice-receiving, "caua" in common. (The "cauas" are ordinarily numbered in an opposite direction to that in which the juice proceeds in the course of manufacture, No. 1 always being the one where the final boiling is done.) The two batteries are fired through the furnace doors close under the No. 1 "caua" in order that the heat may be most intense and easily controlled at this point, and either side may be used independently of the other if desired, while by placing a multitubular boiler directly back of No. 5, where the two furnace chambers converge into one, sufficient steam to run the engine may be generated from the heat of the waste furnace gases, without the use of extra fuel, although of course a separate firing door for the boiler and a by-pass to lead the heat from the battery directly up the chimney, if necessary, must be provided, so that either grinding or boiling may be carried on independently.

Clarification of the juice.—The freshly expressed juice flows from the mill bed through an open wooden trough, generally being strained through a cloth or wire screen to remove suspended particles of bagasse, etc., into "caua" No. 5, where it is warmed up to 70° or 80° and some of the lighter impurities rise to the surface in the form of a froth, which is skimmed off and thrown into the scum tanks on the side. From time to time, as it is required, juice is ladled with a kerosene tin fixed to the end of a wooden pole from No. 5 to the smaller "cauas" No. 4 on either side, the idea being to keep them so nearly full that scums rising to the surface here will again tend to flow back into No. 5.

Liming.—Lime is generally added in two stages, the juice being about half neutralized in No. 4 and tempering completed in No. 3, where the first violent ebullition occurs; sometimes a handful or so will be thrown into No. 5, and if the "maestro" is in doubt as to the amount required, he may even correct an underlimed juice by adding lime a little at a time up as far as No. 2, or, very rarely, even in the "caua de puntos." This process of defecation, is always under the personal charge of the "maestro de azúcar," or chief sugar boiler, a native of many years' experience, who may receive as high as a peso a day for his services. The process is the following: About half a coconut shell full of dry lime (half a kilo) is thrown into a ladle, which is then half filled with hot juice, and, after a few seconds' shaking to promote solution, emptied slowly into the "caua," leaving most of the undissolved lime at the bottom of the ladle, which is refilled with hot juice and poured out again in a similar manner, until only the larger pieces of undissolved lime, about a third of the whole, remain as a residue; these are then thrown into the scum tanks.

Since a brighter colored, although less clean, sugar is thus produced, the tendency among the "maestros" is toward under, rather than over, liming, leaving a juice still very slightly acid to litmus.[25] A good "maestro" knows by instinct, bred of long practice, just when the juice is properly tempered, he judging largely by the peculiar alkaline odor given off as the neutral point is approached, and also by the appearance of the juice when poured out in a thin stream, it changing in color from a dark olive brown to a somewhat lighter, yellowish tinge when sufficient lime has been added. As the limed juice in No. 3 begins to boil, the impurities are coagulated, rise to the surface, and overflow into No. 4 and sometimes into No. 5, where they are skimmed off and thrown into the scum tanks.

This process of surface clarification is continued in No. 2, which is in reality almost a part of No. 3, juice overflowing from one to the other and being ladled back again intermittently, becoming cleaner and more concentrated all the time.

The lime used comes chiefly from the neighboring island of Guimaras, and is of execrable quality. It is invariably slaked directly after burning, some kilns, it is said, even using sea water for this purpose, and is stored and shipped either in bulk or in bags or "bayones" of "buri" leaf such as are used for packing sugar, so that by the time it has reached Negros it has had an excellent opportunity to become converted into the carbonate, which is practically useless for clarification. According to Geerligs[26] lime used for clarification should fill the following specifications:

"When mixed with half its own weight of water it should become very hot within a few minutes. The slaked lime after the addition of ten times its weight of water should form a soft cream, which on being passed through a fine sieve should not leave behind more unslaked particles than one-tenth of the original

[25] Litmus paper, by the way, is still a decided curiosity in Negros, and as far as I know there is not a sugar maker in the entire island who regularly makes use of this or any other indicator as an aid in defecation.

[26] Cane Sugar and its Manufacture. Manchester (1909), 160.

weight, and most of these particles should become soft after an hour's standing in a moist condition. The lime, after being slaked, should dissolve in hydrochloric acid without appreciable effervescence and not leave more than 2 per cent insoluble matter. The maximum percentages of impurities should be:

	Per cent.
Iron oxide and alumina	2
Sulphuric acid	0.50
Magnesia	2
Silica	2
Carbonic acid	2
Moisture	2

A sample of the lime used in Negros as tested there was found to contain about 50 per cent of hard lumps, which would not soften when mixed with water. On treating it with dilute hydrochloric acid, the greater portion of it dissolved, although very slowly, and with much effervescence. A sample was bottled and sent to the Bureau of Science, Manila, where it was analyzed by Mr. L. A. Salinger:

	Per cent.
Loss on ignition	36.81
Iron oxide and alumina	1.39
Magnesia	8.35
Silica	1.42
Calcium oxide	51.42
Total	99.39
Carbonic acid	10.81

Its high percentage of magnesia alone should cause it to be rejected. Subtracting from the total lime that portion present as the carbonate leaves only 37.66 per cent of calcium oxide, as such, in the mixture, and a large proportion of this is in such hard lumps as to be unavailable for clarification. From the standpoint of economy, a fairly pure quicklime would be cheaper at three times the price.

Boiling to a concrete.—When a "cocida" or strike of "massecuite" has been taken out of the "caua mayor," the latter is refilled as quickly as possible (a few minutes' delay might cause the kettle to become overheated and crack) with sirup from No. 2, which by this time has become fairly clear and has been concentrated to about 50° Brix; fresh bagasse is thrown on the fire, and in a short time the pot begins to boil furiously. As the sirup evaporates it is replenished from No. 2, and any last, remaining, flocculent impurities rising to the surface are swept back into the latter. When the "maestro" decides that sufficient sirup has been taken in to yield a "cocida" of the desired size—from 100 to 300 kilos of sugar are taken out at a time—he declares No. 1 "caua" closed, and no further additions are made to it, but the whole mass is boiled down as rapidly as possible until a small sample taken with a stick shows it to be of the proper consistency to take out. At this point the fires are drawn and the "massecuite" poured out into wooden trays, termed "enfriaderas," where it is "crystallized in motion" by stirring with a spade. The time required for crystallization depends much upon the kind of sugar produced, and an experienced sugar maker can, from the behavior of the "massecuite" in the "enfriaderas," form a pretty accurate opinion of the quality of sugar which is being turned out. A high-grade "massecuite" will begin to boil up almost as soon as it strikes the cooling trays, and will subside quickly, only to rise up again in a minute or so. If this rising and falling is very energetic and occurs two or three times in quick succession, it is

a sign of a good "No. 1" sugar, which will be completely dry inside of fifteen or twenty minutes.

The phenomenon is very probably caused by the large amount of heat suddenly liberated, as a part of the sugar crystallizes from its supersaturated solution on striking the cold boards. This might bring about a partial solution of some of the sugar, but as the mixture is stirred and grows cooler more water is evaporated, and other sudden crystallizations take place. "No. 3" sugar will only rise up in the "massecuite" once, and takes a longer time and more stirring to crystallize properly, while low-grade "corriente" simply spreads out in a thin layer like molasses, and may need to be stirred for an hour or more before it shows any signs of crystallization.

Local names for juice, sirup, and the sugar derived from them in various stages of manufacture.—The native sugar boilers have a rather complete nomenclature for the different juices and sirups during the process of manufacture, no less than eleven distinct stages being recognized from the raw juice to the finished product. These are:

1. *Intus:* The raw juice as it comes from the mill.
2. *Lasó:* Juice which has been boiled and clarified.
3. *Almibar:* The thin sirup in the No. 2 "caua."
4. *Pulut:* Thick sirup, the first stage of concentration in the "caua de puntos" (literally, "kettle of stages").
5. *Pulut gabotón:* A very thick sirup which sticks to or tends to pull out the teeth when eaten ("gabotón"=to pull out).
6. *Pasagi:* At this stage a sample removed and cooled in water can be molded and will just hold its shape. The sirup sometimes tends to boil over at about this point, in which case 20 or 30 cubic centimeters of coconut oil, or an emulsion made by squeezing out fresh coconut meat, are added, which lessens the violence of the boiling, and, at the same time is said to prevent the mass from sticking to the bottom of the kettle and burning.
7. *Batok:* A small sample of the sirup cooled in water and formed into a sharp-pointed cone will penetrate a stalk of cane brought down with force upon it.
8. *Butum:* A sample when cooled can be pulled out into a thread without breaking. Sometimes a native "taffy" candy, termed "butum-butum," is made from a portion of the sirup which has arrived at this stage ("butum"=to pull).
9. *Bali:* A sample dropped into cold water becomes somewhat brittle, so that a fine thread will break sharply without much bending. The "massecuite" is generally taken out at this stage ("bali"=to break).
10. *Polvos:* The fine threads, cooled as above, are very brittle and break like glass. This stage is reached only when very good, dry sugar is being made. Sugar from an impure juice will begin to stick to the "caua" before this point is reached.
11. *Calamay:* Sugar, the finished product.

Losses during boiling.—Since no molasses is produced in Negros, the clarified juice being boiled directly to a concrete, the calculation of losses of sucrose incurred is somewhat simplified, and a factory control would be a comparatively easy matter were it not for the fact that nowhere in the Island is any record kept of the weight of canes entering the mill, or the weight or volume of juice boiled, nor are any large scales or other facilities available for accurately determining these rather necessary figures. Losses during the boiling-down process may result from—

(1) Sucrose thrown away with the skimmings from the different "cauas," settlings from the clarifying tanks, and filter-press mud. (2) Sucrose inverted by prolonged boiling at ordinary atmospheric pressure, as indicated by an increased ratio of reducing sugar to sucrose in the final product over that found

in the original juice. (3) Sucrose burned or caramelized during manufacture, together with that first inverted and then completely destroyed by the combined action of lime, lime salts, and excessively high temperatures. (4) Mechanical losses, including juice, sirup, and "massecuite" spilled in the handling, and sugar spilled, stolen, or eaten by the workmen.

Scums.—The per cent of sucrose in the scums, etc., which are thrown away, is always very high, since the juice adhering to these has, by the time clarification is completed, become much more concentrated than the original, raw liquid. A few representative analyses of these waste products will serve to show the considerable amount of sugar which may be carried away by them:

Skimmings from unlimed mill juice in a preliminary clarifying tank.—These consist largely of fine particles of bagasse, mixed with froth and juice, which are thrown into a basket suspended over the tank and allowed to drain without pressure, then thrown away. The sample contained 25.2 per cent total solids and 17.9 per cent sucrose.

Skimmings from caua No. 5, which were not considered worth pressing, but were thrown away at once, contained 29.3 per cent of total dry substance and 22.8 per cent sucrose.

Filter-press mud.—In this instance a large receptacle located between "cauas" No. 4 and No. 3 served as a sort of settling tank, being filled with hot, partially limed juice from No. 4, which after settling for an hour or so was decanted into No. 3. As in the meantime unclarified juice was continuously being ladled directly from No. 4 to No. 3, the advantages of the system are not obvious. The settlings from this tank, about one-fourth its total volume, were run into sacks, on top of which were placed pieces of old iron, car wheels, etc., and the whole allowed to drain for half a day until it had nearly stopped dripping, when the sacks were emptied of the remaining sludge, which was thrown away. A sample of this sludge was found to contain 23.2 per cent sucrose.

Of course, there are some few factories in Negros where such large losses are not incurred, but the instances cited above represent rather better working than the average, many places allowing scums and settlings to run to waste directly, without any attempt at filtration.

There are two or three fairly modern, steam-heated filter presses on the Island, but they do not appear to have given universal satisfaction, principally because of the lack of intelligent labor to operate them, and the consequent trouble due to leacks, broken filter cloths, etc. A very simple, and yet fairly efficient form of scum filter found working in the district of Bais consists of a square wooden box of a little over a cubic meter capacity, provided with a perforated double bottom and a plunger at the top, forced down by a very heavy screw. The scums are filled into ordinary flour sacks, which are tied up tightly and piled inside the box; pressure is then brought to bear, at first slightly, but finally with much force, so that the resulting cake is said to come out almost as dry as ordinary filter-press cake. About one hour is required to fill this press, and two and a half hours to empty it, about four presses full, or 4 tons of scums, being treated per day. As fully half of this, containing at least 20 per cent of sucrose, would otherwise be thrown away, the press causes a saving of about 400 kilos of sucrose, or, at the present price of sugar, about 50 pesos per day. The whole affair cost less than 200 pesos to make, including 150 pesos paid for the screw, and, considering the class of labor available for working it, is probably about as efficient for a small factory as the more costly modern filter presses.

Inversion losses.—With a view of determining the losses occasioned by the conversion of sucrose into reducing sugars, tests were made at two haciendas of the juices and sirups in the various "cauas" covering periods of about half a day each:

SUGAR-BOILING TEST, HACIENDA CARMENCITA, PONTEVEDRA (FEBRUARY 9, 1909).

The equipment consists of two sets of "cauas," six in a series, worked independently, and two large clarifying tanks, which in reality serve more as storage tanks, since very little clarification takes place in them, and the raw juice is often run directly from the mill to the "cauas" without entering the tanks at all. Ordinarily, the juice is pumped from the mill bed to these tanks, where it stays from fifteen to thirty minutes, and is heated by exhaust steam to about 60°, some of the lighter impurities in the meantime rising to the surface and being skimmed off. The warmed juice flows by gravity from the tanks into "caua" No. 6, and when this is full overflows into No. 5, where it remains some fifteen minutes before liming. Juice begins to boil in Nos. 3 and 4, which soon boil over, and the scums are swept back into No. 5, there to be skimmed off and thrown into a scum tank. Aside from these details, the procedure is the same as that previously described. As it is only a semicontinuous process, juice being periodically ladled from one kettle to another as each "cocida" is taken out and "caua" No. 1 emptied, an attempt was made to follow the course of one lot of juice, taking samples each time it was transferred from one "caua" to the other throughout the series. It was found impossible to do this absolutely, since the juice in each "caua" is always more or less mixed with that boiling back from the one in front or ladled in from the one behind it. As canes from the same field were being ground, the mill juice was fairly constant, so that but little variation can be attributed to this factor.

Sample.	Reaction to litmus.	Brix.	Sucrose (direct polarization).	Quotient of purity (apparent).	Reducing sugar.	Reducing sugar per 100 sucrose.
			Per cent.		*Per cent.*	
Raw mill juice in clarifying tank	Acid	18.63	16.92	90.84	0.86	5.08
Juice warmed to 60° C. as it enters "caua" No. 6 (almost the same as first sample)	do	18.64	16.83	90.28	0.91	5.40
Juice which overflows from No. 6 to No. 5; sample taken after No. 5 had been filled, but before liming	do	18.89	16.90	89.41	0.93	5.50
Limed juice as it enters No. 4	Very slightly alkaline.	19.39	17.30	89.23	0.89	5.14
Partially clarified juice entering No. 3	Neutral	30.74	27.26	88.69	1.56	5.72
Clarified juice entering No. 2	do	34.92	31.04	88.92	1.83	5.89
Clear sirup entering No. 1	do	55.04	49.16	89.33	2.86	5.82
Sugar produced	do		86.71		5.9	6.8

A barely perceptible inversion apparently took place as long as the raw juice was being heated without liming, as shown by the increase of reducing sugars over sucrose. The excess of lime in the fourth sample evidently had a slightly destructive action on the invert sugars formed, since their ratio to sucrose drops a trifle. From here on it increases slowly, but the final ratio in the sugar produced is only 1.7 per cent higher than that of the original juice, so that very little loss can be traced directly to inversion, as shown by the reducing sugar ratio. The probabilities are that very much more inversion has actually taken place than is here indicated, but that, owing to the well-known destructive action of lime salts on glucose and fructose at high temperatures, these products have been immediately decomposed into carbonic, formic, and acetic acids, etc., and hence can not be detected by analysis. The apparent purity of the juice falls slowly, down to the

last two samples, where it has become almost completely clarified, and where it rises slightly; the difference is so small, especially at the higher concentrations—a difference of 1° in purity here would be caused by a difference of 0.2° in the Brix of the diluted (1 to 4) sirup—that it might almost be caused by experimental error.

SUGAR-BOILING TEST, HACIENDA LUMAÑGUB, BAGO (MARCH 4, 1909).

The boiling pans here are arranged in the customary manner in two parallel series of four "cauas" each, having a large No. 5 in common. The mill juice falls first into a preliminary clarifier or juice warmer, consisting of a rectangular tank set over the furnace, just back of "caua" No. 5, and provided with wooden partitions at the top and bottom, leaving only a narrow slit in the center for the mill juice to pass through, so that some of the lighter impurities can be removed as scums from the top, while much of the heavy dirt settles to the bottom. Stopcocks at the farther end of the tank permit juice to be drawn off at two levels. As the juice only remains here a few minutes, is only heated to about 65° and not limed, no real clarification can take place, but the arrangement seems to be of some value in mechanically removing sand and dirt and fine particles of bagasse. Lime is first introduced in "caua" No. 5, and augmented, if necessary, in Nos. 4 and 3. Juice begins to boil in No. 3, and at times in No. 4. Samples were taken from the various "cauas" of the hot "massecuite" as it was ladled out from the "caua mayor," and also of the sugar made, every time a "cocida" was taken out during the course of the afternoon. In this experiment no attempt was made to follow the course of any one particular lot of juice, but I desired rather to determine the average composition of the juice and sirups in the different kettles. Cane from the same field was being ground during the entire day and the mill juice was of practically uniform composition throughout the test. The mixed samples analyzed as follows:

Sample.	Reaction to litmus.	Brix.	Sucrose (direct polarization).	Quotient of purity (apparent).	Reducing sugar.	Reducing sugar per 100 sucrose.
			Per cent.		*Per cent.*	
Raw mill juice as it enters preliminary clarifiers	Acid	20.95	19.73	94.21	0.38	1.92
Mill juice flowing from clarifier into "caua" No. 5	do	21.33	20.03	93.89	0.39	1.94
Limed juice from No. 5 as it is ladled into No. 4	Slightly alkaline.	25.68	23.47	91.41	0.49	2.08
Limed and partially clarified juice from No. 4 as it is ladled into No. 3	do	30.12	27.38	90.86	0.74	2.70
Clarified juice from No 3 as it enters No. 2	do	30.82	28.06	91.05	0.75	2.27
Clear sirup from No. 2 as it enters No. 1	Neutral	44.16	40.86	92.53	1.01	2.05
"Massecuite" from No. 1 as it is poured into the "enfriadera" (diluted to approximate Brix of mill juice (1–4) and analyzed as such)	do	95.08	88.16	92.72	3.04	3.46
"Massecuite," analyzed as sugar		[a]94.40	88.39	93.63	3.04	3.44
Sugar after crystallizing and cooling		[a]97.32	90.59	93.09	3.37	3.72

[a] Total solids by drying.

As in the previous test, only a slight inversion can be detected up to the time the juice is fully limed; here the formation of reducing sugars seems to continue to some extent, even with an alkaline reaction to litmus in "caua" No. 4, but, owing to the destructive effect of the lime, the "glucose" ratio diminishes again from this point on until the final boiling takes place in No. 1, where it is much increased.

Since reducing sugars are so easily decomposed at the temperatures which must exist during this final boiling, it is impossible to determine just how much inversion does take place at this stage of the process, but it must be considerable in amount, as the proportion of reducing sugar to sucrose is always decidedly larger on leaving than on entering this "caua," and the increase continues even while the hot "massecuite" is being crystallized in the "enfriaderas." The purity of the juice diminishes gradually during the first heating until clarification is nearly complete, when it again increases. The purity of the last two samples, calculated on the percentage of total solids obtained by drying in an oven to nearly constant weight, is naturally higher than that of the previous ones which were figured on degrees Brix; the difference here is less marked than is generally noted in massecuites from modern sugar factories, the reason probably being that low-grade sugars of the open-kettle type always carry a certain percentage of insoluble impurities such as sand, dirt, bits of bagasse, etc., which raise the true total solids of the "massecuite" without affecting its specific gravity, thus counteracting in a measure the high Brix readings caused by salts in solution.

From the above tests it is clear that, even with the old open-kettle process of sugar boiling, there is comparatively little loss to be feared by inversion while evaporating the juice down to a density of 50° or 60° Brix, preliminary to the real sugar boiling which takes place in "caua" No. 1, provided reasonable care is taken in liming so as to have the juice either neutral, or very slightly alkaline or acid. This is what might be expected theoretically, since this first evaporation, corresponding approximately to that carried on in modern works in the multiple effects, is seldom carried further than a density of 55° Brix, and even at atmospheric pressure the boiling point of a sugar solution of this concentration is not very high.

Gerlach[27] determined the boiling point of aqueous sugar solutions as follows:

Sucrose.	Temperature.
Per cent.	*°C.*
10	100.4
20	100.6
30	101.0
40	101.5
50	102.0
60	103.0
70	106.5
80	112.0
90.8	130.0

For the purpose of calculation, it may be assumed that the juice is heated in "cauas" Nos. 5, 4, 3, and 2 for a period of four hours, and has during that time an average sugar content of 30 per cent. Herzfeld,[28] working with very slightly alkaline solutions of pure sucrose, found that in one hour the percentage loss by

[27] *Z. Ver. Zuckerind.* 13, 283.

[28] *Z. Ver. Zuckerind.* 43, 745.

inversion in a 30 per cent solution at 100° was 0.0423, and at 110°, 0.0557. Assuming that the impurities in a cane juice raise the boiling point up to even 105°, during the four hours, there would only be lost about 0.2 per cent of total sucrose by inversion. Local overheating of the pans, and boiling the juice before it is completely neutralized, will raise this figure somewhat, but it may be safely stated that ordinarily less than 1 per cent of sugar is lost by inversion prior to boiling down in the "caua mayor."

Sucrose burned in manufacture.—While sugar solutions of moderate concentration may be heated for a long time with little loss, when they are highly concentrated a much more rapid inversion takes place. Eckleben [29] found that an 85 per cent sugar solution heated in a closed vessel at 120° to 125° was completely inverted in six hours. The "massecuite" from the No. 1 "caua," since it contains as a rule only from 5 to 10 per cent of water, must attain a temperature of from 120° to 130° during the last stages of concentration, and owing to imperfect circulation and conduction of heat in such a thick solution, the temperature of that portion in immediate contact with the sides of the kettle is necessarily much higher. As has been previously explained, only a small percentage of the total inversion occurring here can be determined analytically, since the invert sugar formed is rapidly decomposed at this high temperature.

Probably the largest losses incurred in the process of manufacture take place in the "caua mayor" during the last fifteen or twenty minutes' boiling of each "cocida," and the longer it is necessary to keep the "massecuite" in this pan the greater becomes the loss. A "massecuite" of high purity can be concentrated rapidly without so much danger of sticking to the pan and burning, since sucrose is more soluble in the water of such a "massecuite" than of one containing more impurities [30] consequently it remains in solution longer and boils more uniformly.

An impure sirup, during the first half of its evaporation in the final kettle, may appear as light colored as any other, but, as it becomes thicker and hotter, decomposition of the invert sugar begins, giving rise to dark-colored products, some of which, probably, being of an acid nature, cause still more inversion of sucrose. Sometimes a "cocida" will boil along very smoothly for a time, then suddenly turn dark and begin to stick to the pan, at times bumping with sufficient violence to scatter hot "massecuite" clear out of the pan. In such cases any attempt at further concentration is generally useless, as the sugar decomposes rapidly, often giving off smoke and acrid vapors, and it can never be made to crystallize properly. Boiling too much "massecuite" at one cooking, poorly arranged "cauas," inefficient firing, poor fuel, in fact anything which prolongs the stay of the "massecuite" in the first kettle, increases the loss by burning. This fact is well appreciated by the planters in general, who say that it is very difficult to produce good sugar in rainy weather, even from excellent cane, since the bagasse can not be sufficiently dried to give a hot fire.

Mechanical losses.—These are, of course, impossible to determine separately. They will be estimated together with those due to burning in manufacture in the calculation of the percentage yield from the cane, which is given in a subsequent portion of this paper.

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[29] *Z. Ver. Zuckerind.* 40, 817.

[30] Geerligs, Cane Sugar and its Manufacture. Manchester (1909), 225.

QUALITY OF SUGAR PRODUCED IN NEGROS.

Negros sugar, as sold in the Iloilo market, is classified commercially under two main headings, "Superior" and "Wet," according to whether it polarizes above or below 80°.

The "Superior" sugar is subdivided as follows:

No. 1, from 88°.9 (or higher) to 87°, inclusive, average, 88°.
No. 2, from 86°.9 to 85°, inclusive, average, 86°.
No. 3, from 84°.9 to 80°, inclusive, average, 82°.5.

The difference in price between grades has ordinarily been 25 centavos per picul of 63.25 kilos. The fact that practically all Iloilo "Superior" sugar is now bought for shipment to New York is of late beginning to disturb this simple and harmonious price difference between grades. According to the New York basis of 0.1 cent gold per pound for each degree difference in polarization up or down, the difference in price between Nos. 1 and 2 would be 56 centavos per picul, and between Nos. 2 and 3, 98 centavos per picul. Large purchases of "Superior" sugar are generally based on an arbitrary assortment, originally supposed to represent the average proportion of the different grades produced, which is one-eighth (or 12.5 per cent) of No. 1, two-eighths (or 25 per cent) of No. 2, and five-eighths (or 62.5 per cent) of No. 3, the price for assorted being half-way between No. 2 and No. 3, and its average polarization being 84°. Of late years rather more No. 1 has been produced and less of Nos. 2 and 3 than is called for by "basis assorted," although the average polarization is about the same. The records of "Superior" sugar received by one firm during five years were: No. 1, 26 per cent; No. 2, 18 per cent; and No. 3, 56 per cent—the average polarization of the lot coming to 84.4 per cent.

Sugar polarizing less than 80° is classed as:

"Humedo" (wet), from 79°.9 to 76°, inclusive.
"Corriente" (current), from 75°.9 to 70°, inclusive.

"Humedo" is quoted at about 1 peso less than No. 3, while "corriente" has no fixed ratio to the other grades. The relative amounts which are produced of these two grades are rather difficult to estimate, since much is mixed together and sold to Chinese buyers as "wet" sugar regardless of its polarization, while the better grade of "humedo" is frequently worked off by blending it in small quantities with No. 3 "Superior." Climatic conditions during different years also affect the proportion of low-grade sugars turned out, but they rarely exceed 20 per cent or fall below 10 per cent of the total production.

The average quality of the sugar produced in Negros from year to year may be considered, then, to be approximately 85 per cent of "Superior," polarizing 84°, and 15 per cent of "Wet," polarizing 75°, with an average polarization for the whole of 82°.6.

Quality of sugar estimated from tests made in Negros.—In connection with the work of testing the efficiency of mills, samples of mill juice and of the sugar being made at the time were analyzed as follows:

Table showing the composition of the mill juice and the quality of the sugar produced by a number of mills in Negros.

Test No.	Mill juice.				Sugar made.		Reducing sugar per 100 sucrose.	
	Brix.	Sucrose.	Quotient of purity.	Reducing sugar.	Polarization.	Reducing sugar.	In juice.	In sugar.
1	18.70	14.84	79.16	2.46	----------	----------	16.6	----------
2	17.83	15.11	84.78	1.44	83.9	7.7	9.5	9.2
3	17.86	14.14	79.47	----------	82.8	8.4	----------	10.1
4	19.00	16.32	85.90	0.98	----------	----------	6.0	----------
5	16.65	14.29	85.82	1.21	76.2	12.8	8.5	16.8
6	17.12	14.20	82.96	1.56	77.1	11.8	11.0	15.3
7	19.74	17.23	87.26	----------	----------	----------	----------	----------
8	20.93	19.32	92.30	0.56	84.7 90.3	8.0 3.7	2.9	9.4 4.1
9	21.34	19.54	91.60	----------	----------	----------	----------	----------
10	20.70	19.63	94.82	0.26	88.2	5.1	1.3	5.8
11	20.30	17.94	88.37	1.12	84.6	7.9	6.2	9.3
12	20.35	18.03	88.61	0.98	87.9	5.2	5.4	5.9
13	20.45	18.71	91.47	----------	----------	----------	----------	----------
14	20.30	17.77	87.04	0.89	86.6	6.3	5.0	7.3
15	20.86	16.18	77.57	2.76	68.6	17.4	17.0	25.4
16	18.47	15.81	85.73	1.36	79.8	10.6	8.6	13.3
17	19.79	18.12	91.58	0.51	84.0	7.3	2.8	8.7
18	20.98	18.87	89.93	0.75	84.6	8.1	4.0	9.6
19	22.93	20.99	91.56	0.51	81.5	----------	2.4	----------
20	19.10	15.72	82.31	1.61	76.7	12.1	10.2	15.8
21	20.98	18.35	87.48	1.30	80.7	8.6	7.1	10.6
22	19.74	16.37	82.92	2.06	68.4	15.8	12.6	23.1
23	18.77	15.70	83.68	1.50	78.3	9.5	9.6	12.1
24	17.57	14.93	85.00	1.17	85.0	8.4	7.8	9.9
25	21.06	19.18	91.07	0.69	84.5	7.6	3.6	9.0
26	19.40	17.10	88.20	----------	86.4	----------	----------	----------
27	18.63	16.92	90.84	0.86	86.7	5.9	5.1	6.8
28	20.95	19.73	94.21	0.38	90.6	3.4	1.9	3.8
29	23.13	21.11	91.26	0.60	85.1	5.2	2.8	6.1
30	17.76	13.85	77.94	2.37	68.6	17.6	17.1	25.6
Average	19.71	17.20	87.03	1.20	82.0	8.9	7.4	11.4

Since no one sample of sugar could fairly represent the entire output of the hacienda from which it was secured, the sources of the different samples are not given, although it may be stated that they were taken from mills in the district of Bago, Pontevedra-La Carlota, Ilog-Cabancalan and San Carlos, and covered a period of time of about six months, or practically the entire grinding season of 1908–9, so that the average composition of the juices and sugars given should not be far from that of the whole island during that time. As a matter of fact, although possibly through coincidence, the average polarization of the sugar herein shown,

82°, agrees fairly closely with that just deduced from the records of sugar bought in Iloilo, 82°.6.

Examination of this table shows that there is much room for improvement in the manufacture of sugar as now carried on, even with the open-kettle process. Reduced to its simplest terms, this process consists merely in removing the water from a solution containing a certain percentage of sucrose, reducing sugars, salts, and organic matter not sugar, which, if evaporated to complete dryness under ideal conditions, would yield a product having the same polarization as the "quotient of purity" of the original juice. Clarification with lime, coupled with the increase shown by "true" over "apparent" purity, would still further raise the final polarization, so that it is theoretically possible to produce a concrete having a polarization a few degrees higher than the original purity of the juice. In the best practice this would be reduced from 2° to 5° by the hydration water necessarily retained by the reducing sugars and salts present, so that perfect sugar boiling, where no molasses is removed, might be considered to be the production of a concrete having the same polarization as the original "apparent" purity of the juice.

This limit is in rare cases rather closely approached, the two mill tests previously quoted, which represent very fair work, falling below it by 3° or 4°, while in the average of all the samples examined the polarization of the sugar made is 5° less than the original purity of the juice. Number 8 indicates the extent to which the quality of sugar produced may be influenced by care in manufacture; in this case a juice of 92.3 purity was yielding sugar which polarized only 84.7, the native sugar boiler in charge laying the blame on the canes ground, which, he said, were of inferior quality. The manager of the estate, acting on a suggestion to try a change of sugar boilers, brought over an experienced "maestro" from another estate, with the result that, from juice of identically the same quality, sugar polarizing 90.3 was produced. This gave a net gain of 50 centavos per picul in the price realized, or about 50 pesos per day. In each case the juice had been limed until it was practically neutral, the only difference in manipulation being the greater care and skill exercised by the more experienced "maestro" in supervising the final operation of boiling, and in allowing only thoroughly clarified juice to enter the No. 1 "caua."

It is an astonishing fact that so little attention is paid in Negros to the importance of skill and care in the manufacture of sugar, even by the present crude methods. Many planters, industrious and painstaking to an extreme degree as far as planting and field operations are concerned, appear to consider that once they have succeeded in raising a large crop of good and healthy cane their responsibility has ceased, and the details of manufacturing are turned over to a native contractor at so much a picul, or, if the mill is run by laborers furnished by the hacienda, a foreman may be nominally placed in charge, but the quality of sugar produced depends solely upon the

skill and the faithfulness of a native "maestro," who rarely receives more than 1 peso per day for his expert services. It may appear a broad statement, but it is one capable of demonstration, that not one planter in twenty is capable, in case of necessity, of himself going into the mill house, liming the juice properly, supervising the clarification, and determining the right concentration at which to remove a "cocida" of "massecuite" in order to secure the best quality of sugar therefrom.

COST OF MANUFACTURE.

If sugar is made by contract, the work is generally divided into the three operations—grinding the cane, boiling the juice, and drying the bagasse; the contract prices (in pesos per picul of 63.25 kilos) varying according to local conditions as follows:

Operation.	Highest.	Lowest.	Average.
Grinding the cane	0.17	0.08	0.15
Boiling the juice	.16	.08	.15
Drying the bagasse	.16	.08	.12
Total			.42

To which must be added:

	Pesos.
Oil for lubrication	0.02
Bags (2 per picul)	.12
Rattan for tying up bags	.02
Extra wages to sugar boiler and engineer	.03
Extra for labor of packing in bags and carrying to storehouse	.04
Lime and coconuts or coconut oil	.02
Extra wood for boiler when bagasse is insufficient	.05
Total	.30

This makes a total cost of manufacturing sugar by contract of 72 centavos per picul, or 11.37 pesos per metric ton.

Of course, the above includes a certain profit to the contractors. When sugar is made exclusively by day laborers paid by the hacienda, the cost is generally somewhat less. For example, the typical hacienda previously assumed for the purpose of calculating the cost of cultivation, producing annually 6,000 piculs or 379.5 metric tons, would, allowing for stops and delays because of bad weather, etc., need a mill of about 8 nominal horsepower, with batteries of corresponding capacity, capable of turning out an average of 80 piculs, or about 5 metric tons, of sugar per day in order to grind the whole crop in three months or seventy-five actual working days. The daily expenses of operating such a mill would be approximately as follows.

Estimate of the approximate daily cost of operating a sugar mill in the Island of Negros, producing an average of 80 piculs or 5 metric tons of sugar per day of fourteen hours, no charge being made for supervision, depreciation of the plant, or interest on the capital involved.

Item.	Cost in Philippine currency.	Item.	Cost in Philippine currency.
	Pesos.		*Pesos.*
1 "maestro," or sugar boiler	1.00	8 "suplillos," for transferring juices and sirups from one "caua" to the other, at 40 centavos each	3.20
1 engineer	1.00	8 "azucadores," for crystallizing the "massecuite" and packing the sugar in sacks and carrying it to the storehouse, at 40 centavos each	3.20
1 fireman for the engine boiler	.40	To cost of labor, 10 per cent additional for stoppages and delays	2.72
2 water carriers for the engine boiler, at 40 centavos each	.80	Lime for clarification of juices (1.5 cavanes, at 0.50 centavos per cavan)	.75
4 firemen for the batteries, at 40 centavos each	1.60	Coconuts or coconut oil for use in "caua" No. 1	.50
10 "cambiadores," for unloading cane and carrying it to the mill, at 40 centavos each	4.00	Lubricating oil for engine and mill	.75
2 "planchadores," for feeding the mill, at 40 centavos each	.80	Grease for mill	.50
6 "manogsalu," for carrying bagasse from the mill to the plaza, at 40 centavos each	2.40	Firewood for boiler when bagasse supply is insufficient	4.00
20 laborers for sun drying the bagasse in the plaza and storing it under shelter when dry, at 40 centavos each	8.00	Kerosene oil for lighting the mill house at night	1.00
1 laborer stationed at the mill to keep mill bed free from bagasse and make himself otherwise useful	.40	160 bags, 2 per picul, at 7.00 pesos per 100	11.20
1 laborer to look after the juice canal, etc	.40	1,000 pieces bejuco (rattan for tying up bags)	2.00
		Total	50.62

The bare cost in the mill house, then, for manufacturing 80 piculs or 5.06 metric tons of sugar may be placed conservatively at 50.62 pesos, which is at the rate of 63 centavos per picul, or 10 pesos per metric ton.

TRANSPORTATION AND SALE OF THE SUGAR.

Growing the cane and manufacturing it into sugar does not end the labors of the planter in Negros; he must bring the sugar to the seacoast or the closest lorcha anchorage, load it, and arrange for its reception and sale at Iloilo. If he is fortunate enough to own a plantation near the sea or on the banks of some navigable river, loading the boat will only cost him 1 or 2 centavos per picul (16 to 32 centavos per metric ton), while his neighbors farther inland must bring their sugar down a few tons at a time in carabao carts over not the best roads in the world, paying in extreme cases as high as 30 centavos per picul (4.75 pesos per metric ton). The average planter pays probably 10 centavos per picul, or 1.58 pesos a metric ton. Transportation

to Iloilo, as has already been stated, is effected in lorchas—small, flat-bottomed schooners especially built for this trade, of very light draft, and having a capacity of 100 tons or less—the freight rate varying, according to distance, between 15 and 30 centavos per picul (2.37 to 4.74 pesos per metric ton) and averaging 20 centavos per picul (3.16 pesos per metric ton). Once in Iloilo, the sugar is taken in charge by the planter's agents, who attend to the discharging, weighing, classifying, repacking, etc., and either sell it at the market rate, or store it subject to orders in their warehouses.

Cost of shipping the sugar to Iloilo and selling it there.—The expenses ordinarily incurred in disposing of the sugar after it leaves the hacienda, reduced as nearly as possible to average distances and costs, are summarized in the accompanying table:

Estimate of the approximate cost of transporting sugar from a plantation on the Island of Negros to the city of Iloilo and there selling it, charges being quoted in Philippine currency per picul and per metric ton.

Item.	Per picul.	Per metric ton.
	Pesos.	*Pesos.*
Transportation to the lorcha landing and loading aboard the lorcha	0.10	1.58
Freight from Negros to Iloilo	.20	3.16
Discharging in Iloilo	.015	.24
Replacing 15 per cent of damaged bags (material)	.02	.32
Labor of repacking	.04	.64
Weighing	.008	.13
Receiving in agent's warehouse	.01	.16
Agent's commission (2 per cent of selling price)	.14	2.22
Total	.533	8.45

QUANTITATIVE EXPERIMENTS TO DETERMINE THE WEIGHT OF SUGAR PRODUCED FROM A GIVEN WEIGHT OF CANE

Although by comparative analyses of cane and bagasse it is possible to determine with considerable accuracy the percentage extraction of juice by a mill, without weighing either the cane ground or the juice and bagasse produced, and while a knowledge of the composition of the juice affords a means of approximating the yield of sugar which might be produced therefrom, it has heretofore not been practicable in Negros, owing to the lack of any large scales for weighing cane, actually to determine the yield in practice. After several unavailing attempts in other places to determine this yield, I was finally enabled through the courtesy of the owners and the manager of the hacienda San Jose, San Carlos, to make two complete chemical controls of the mill at this

place, covering periods of about twelve hours' run each, on two fields of cane of very different composition. The figures resulting from these tests, while necessarily not of a high degree of accuracy, are yet as reliable as it was possible to make them with the limited facilities at hand. As only one pair of scales (with a maximum capacity of 500 Spanish pounds) was available for weighing cane and bagasse, it was found necessary to weigh the cane during the course of one day, store it under shelter over night and grind the next day, thus leaving the scales available for weighing bagasse.

The weight of cane actually ground was calculated by subtracting the loss in water by evaporation as determined from a small sample of 1,000 pounds stored under the same conditions. The bagasse was weighed as it came from the mill, in lots of 200 pounds, a sample of 200 grams being taken from each lot and placed in a box over the boiler to dry for analysis. At the end of the run this was chopped into fine pieces, reweighed, quartered, and analyzed, and results calculated back to the fresh bagasse and the original cane. The weight of juice was estimated by difference between that of cane and bagasse.

Although the customary methods of boiling in this locality were followed with as little deviation as possible, some allowance must be made for the mental strain on the native workmen, who were somewhat at a loss to understand the meaning of such an innovation in their ordinary routine; also for the fact that to avoid fracturing the "cauas" it was necessary to follow up the last boiling of juice with pure water, thus incurring a slight loss of a liter or so of juice left behind in each kettle, which in the usual practice would not have occurred. Furthermore, it may be stated that these tests, although fairly representative of the working of the average sugar house in Negros, are no longer so of the hacienda on which they were made, as an entirely new plant has been installed there within the past six months.

MILL CONTROL NO. 1, HACIENDA SAN JOSE, SAN CARLOS (MAY 1, 1909).

Equipment.—The mill used was of 12 nominal horsepower, rollers 56 by 106 centimeters, power supplied by a multitubular boiler set between the batteries and the chimney, but provided with an independent firing door; steam pressure about 60 pounds to the square inch (4.2 atmospheres). The mill juice runs though an open trough to a series of batteries arranged according to the usual manner, two parallel sets of four in series with the "No. 5" in common. During the experiments one side only was used. No filter presses of any kind were employed, the skimmings from the cauas being thrown into an iron scum tank, which, when full, was allowed to settle as much as possible, the clear juice run back into the battery, and the residue discarded.

Process of manufacture.—With the exception of the liming of the juice, which, for the sake of uniformity, was all made barely alkaline to litmus in the No. 5 "caua," the details of manufacture were left entirely to the native sugar boilers, with instructions to go ahead precisely as was their usual custom.

Kind of cane used.—The cane ground in this test was from the same field as that taken for "cane analysis No. 42;" district of San Carlos, previously quoted as containing fiber 12.51 per cent, sucrose 18.01 per cent, with an exceedingly pure juice of the composition: Brix, 23.0; sucrose, 21.21; quotient of purity, 92.15; reducing sugar, 0.22. The field was not very thickly grown, and the cane itself had been much stunted by exceptionally dry weather, so that the cane stalks averaged only 410 grams in weight. It was estimated by the manager of the plantation that this field would produce about 40 piculs of sugar per hectare (2.5 metric tons). A section comprising 8.663 square meters was measured off, and the cane on it ground, with the following yield:

Cane actually ground, 18,479 kilos, or 21.3 metric tons per hectare.

Bagasse produced, 8,091 kilos.

Analysis of bagasse: Dry substance, 46.38 per cent; sucrose, 11.84 per cent (corresponding to "mill juice" 56.07 per cent); fiber, 33.42 per cent; "mill juice," per 100 fiber, 168.

Juice extracted, 10,388 kilos, of composition: Brix, 23.13; sucrose, 21.11 per cent; "quotient," 91.26; reducing sugar, 0.60 per cent.

Sugar made, 2,060 kilos, of composition: Sucrose, 85.11 per cent; reducing sugar, 5.24 per cent.

Skimmings thrown away, 699 kilos, of composition: Sucrose, 28.72 per cent; reducing sugar, 0.89 per cent.

Without entering into details of the calculation, the percentage yields and losses during the experiment, derived from the above data, may be summarized as follows:

Summary of mill control No. 1.

	Per cent.
Sucrose in cane[31]	17.05
Fiber in cane	14.63
Juice extracted, on weight of cane	56.22
Sucrose extracted:	
In juice, on weight of cane	11.87
In juice, on sucrose in cane	69.60
Raw sugar produced, on weight of cane	11.05
Average polarization of sugar produced	[32] 85.11
Sucrose produced:	
On weight of cane	9.49
On sucrose in cane	55.67
On sucrose extracted in juice	79.98

[31] "Sucrose" in these tests refers to the percentage indicated by direct polarization. True sucrose by Clerget would, of course, be a trifle more.

[32] In ordinary working, the polarization of the raw sugar produced would have been a few degrees higher. In an endeavor to work up as much of the skimmings as possible in the final boiling, some impurities were introduced in the clarified sirup, which resulted in an inferior grade of sugar from this *cocida*. The previous boilings had averaged about 87 polarization. In practice, skimmings are filled into alternate tanks and allowed to stand until they settle, which was impossible in a test of only 1 day's duration.

Sucrose lost—	On weight of cane.	On sucrose in cane.	On sucrose extracted in juice.
	Per cent.	*Per cent.*	*Per cent.*
In bagasse	5.18	30.40	
In skimmings	1.09	6.38	9.17
By inversion (from excess of reducing sugar in final product over that originally present in juice)	0.27	1.56	2.23
Apparent, or analytical (one-third of excess of reducing sugar)	0.09	0.54	0.78
Burned in manufacture, spilled, and unaccounted for	0.93	5.45	7.84
Total loss	7.56	44.33	20.02

The percentage of sucrose lost in the bagasse in this test is considerably higher than is the general rule in Negros, which, as estimated previously, amounts on an average to a little less than 25 per cent of the total sucrose in the cane.

This is not the fault of the mill, which, when tested previously when grinding a similar cane, produced a bagasse containing 169 parts "mill juice" to 100 fiber, while the figure derived from the present new mill is 168, a very close agreement, and somewhat better than the average mill in Negros. The loss rather is due to the larger amount of fiber which these very dry canes carry, this being aggravated by the introduction of about 2 per cent more fiber in the shape of dry leaves, etc. Comparing "Cane analysis No. 42," as made on a sample of 20 canes taken from this field and ground in a hand mill, with the composition of the same field deduced from the present mill control, very little difference will be noted as far as the quality of the expressed juice is concerned; Brix and sucrose agree within 0.1 per cent, although, as the differences are in opposite directions, the indicated purity of the mill juice from the large mill is almost 1 per cent lower than that previously found by analysis; reducing sugar in the mill control is 0.60 per cent against only 0.22 found previously, but the difference is partially accounted for by the fact that the cane ground on a large scale had stood over night before grinding, while the small sample had been analyzed immediately after cutting. Cutting the cane tops a little higher up than was done for analysis might also increase the percentage of reducing sugar.

The extent to which the introduction of cane trash into the mill will reduce the yield of sugar is clearly brought out by comparing these two analyses: The clean cane previously was found to contain only 12.51 per cent of fiber, while the figure derived from the analysis of bagasse during the mill test was, when calculated back to the weight of the cane ground, 14.63, a difference of 2.12 per cent, which could only be due to trash. Since it was found that in the mill 168 parts of juice are held back by each 100 parts of fiber, it is evident that if only clean canes had been ground the extraction of juice would have been 3.56 per cent greater, so that 59.78 per cent of juice on the weight of the cane might have been obtained instead of the 56.22 per cent which it actually yielded. In other words, an increased extraction of juice and consequently of sugar over that really produced, of $\frac{3.56}{56.22}$, or 6.95 per cent, would have resulted, or in case of the average

small factory making sugar to the value of, say, 500 pesos per day about 35 pesos more per day would be gained by having the cane perfectly clean before it enters the mill. Six laborers in the mill at an extra cost of 2.40 pesos per day should be able to free all the cane from trash as it comes from the field and would repay the additional expense for their services many times over. The above remarks should not be construed as reflecting against any one hacienda or district in particular, but apply equally as well in nearly every other part of Negros.

The percentage of sucrose lost in the skimmings, working with such a rich juice and no filter press, was considerably higher than that which might ordinarily be expected, as the scums, because of their high density (sucrose, 28.72 per cent), were very slow to settle, and a tank full yielded only about two-thirds of its volume of clear juice, the remaining third being thrown away. The loss due to caramelization was somewhat less than the average, since less time was required for evaporation, and the fairly pure "massecuite" could be carried down to the desired low-water content with comparatively little danger from burning, so that a very light-colored sugar was produced. The figures denoting loss by inversion have in reality very little value as showing the real amount of inversion taking place, but simply give the amount of invert sugar produced and which happened to escape destruction by overheating, remaining as such in the final product.

Finally, taking into account the large losses of sucrose incurred in milling, and in fact throughout the entire process of sugar making, it should be noted that the actual weight of raw sugar produced, referred to the weight of cane crushed, is by no means as small as might ordinarily be believed. This is so because of the retention of all soluble impurities and molasses in the concrete; so that from the juice extracted as much if not more *low-grade* sugar is yielded by the present process than could be secured from the same amount of juice in the form of 96° crystals by a modern factory, although, of course, the recovery expressed in terms of sucrose is very much less.

Thus, in the present instance 1 ton of cane produced 0.1115 ton of sugar, or to produce 1 ton of sugar required 8.97 tons of cane, a ratio which would be considered very fair work in many countries where even the best and most economical working might not, on account of the poorer quality of cane dealt with, turn out more than 0.1 ton of sugar (96°) per ton of cane. Calculated to the hectare of land, the field used for this test produced 21.33 metric tons of cane and 2.378 metric tons, or about 38 piculs, of sugar per hectare, a very poor yield for the locality, but just about what had been expected, since it was one of the poorest fields in the hacienda.

MILL CONTROL NO. 2, HACIENDA SAN JOSE, SAN CARLOS (JUNE 1, 1909).

Kind of cane used.—The field from which this cane was taken has been discussed under "Cane analysis No. 46," District of San Carlos, where it was cited as an example of the effect of drought on very young cane in changing it from a state of immaturity to one of decay without giving it an opportunity to become fully ripe. The field itself is in general considered one of the best in the locality,

both as to quality and quantity of cane produced, and the same was indicated by analysis, where care was taken to exclude both decidedly immature and dead or decaying canes. The composition of normally developed cane from this field was then found to be: Average weight, 1.06 kilos; fiber, 9.89 per cent; sucrose, 16.76 per cent; juice—Brix, 21.33 per cent; sucrose, 19.26 per cent; purity, 90.31; reducing sugar, 0.85. In practice it was found to be impossible to throw out all the young or the overripe cane before grinding, so that the material actually ground bears no relation to the normal specimens analyzed, but serves as an example of what may be expected from the average mill in Negros when working on an inferior quality of cane and juice. This test was made during the last few days of the grinding season, and the small portion of the field yet remaining to be ground was so irregular in shape that no attempt was made to measure it accurately. Estimated by the eye alone the yield must have been about double that of the field for the previous test, since the individual canes, although of much poorer quality, were more than twice as large, and much more thickly grown. The process of manufacture was carried on precisely as in Control No. 1.

Weight of cane actually ground, 24,520 kilos.

Bagasse produced, 8,810 kilos, of composition: Dry substance, 39.78 per cent; sucrose, 8.18 per cent (corresponding to "mill juice" 59.06 per cent); fiber, 29.29 per cent; "mill juice" per 100 fiber, 202.

Juice extracted, 15,710 kilos, of composition: Brix, 17.76; sucrose, 13.85 per cent; "quotient," 77.94; reducing sugar, 2.37.

Sugar made, 2,311 kilos, of composition: Sucrose, 68.60 per cent; reducing sugar, 17.58 per cent.

Skimmings thrown away, 804 kilos, of composition: Sucrose, 13.7 per cent; reducing sugar, 2.58 per cent.

The percentage yields and losses during this test were:

Summary of mill control No. 2.

	Per cent.
Sucrose in cane	11.81
Fiber in cane	10.52
Juice extracted, on weight of cane	64.07
Sucrose extracted in juice, on weight of cane	8.87
Sucrose extracted in juice, on sucrose in cane	75.13
Raw sugar produced, on weight of cane	9.42
Average polarization of sugar produced	68.60
Sucrose produced on weight of cane	6.47
Sucrose produced on sucrose in cane	54.73
Sucrose produced on sucrose extracted in juice	72.85

Sucrose lost—	On weight of cane.	On sucrose in cane.	On sucrose extracted in juice.
	Per cent.	*Per cent.*	*Per cent.*
In bagasse	2.94	24.87	
In skimmings	0.45	3.81	5.06
By inversion (from excess of reducing sugar in final product over that originally present in juice)	0.21	1.80	2.39
Apparent or analytical (one-third of excess of reducing sugar)	0.07	0.62	0.83
Burned in manufacture, spilled, and unaccounted for	1.67	14.17	18.87
Total loss	5.34	45.27	27.15

The per cent of total sugar lost in bagasse here, 24.87, approaches more nearly the average for Negros, as would be expected from the fiber content of the cane ground. That this latter does not show such a marked increase due to added trash over that previously found by analysis is probably accounted for by the larger proportion of young and tender canes ground in the test, tending to reduce the fiber actually present in the clean cane.

Comparison of the work done by the mills in these two controls emphasizes the fact that we have as yet no reliable standard for absolute mill efficiency which applies when different kinds of cane are being ground. There is no reason to believe that any marked variation in the working of this mill took place between the first and the second test, yet, measured by "extraction," much superior work was accomplished in the latter, 75.13 per cent of the total sucrose in the cane being secured as against 69.60 per cent in the former, while, on the other hand, if we apply Watts's factor of "first mill juice per 100 parts fiber of bagasse" we must believe that the better work was done in the first test, since there only 168 parts mill juice were left in the bagasse per 100 fiber, compared with 202 parts found in the last control. These differences are far too great to be attributed to errors of analysis, and the sampling was conducted in such a manner and over so long a time (the final mixed sample of bagasse from Control No. 2, for instance, was made up of 95 separate 200-gram samples taken at regular intervals throughout the day) as to neutralize by mere numbers much of the unavoidable error inherent to this part of the work. There remains, therefore, only the qualitative difference in the fiber from these two kinds of cane. As a matter of fact, the variety of cane ground was the same in both cases, both being of the common purple kind, although that used in the first test was old, hard, and dry, while the second was comparatively young and tender. Just as in the previously stated results with the hand mill (see p. 95), the fiber from the soft and juicy canes was found to retain a proportionately larger amount of juice than that from the harder ones, although, since the total amount of fiber present was less, the "extraction" was better.

It is possible that this effect of the qualitative difference of cane fiber is peculiar to single crushing, and might tend to disappear in the case of mills run in multiple and with pressure regulators, as is indicated by the recent work of Deerr,[33] who found on analyzing separately the bagasse of the hard rind and the soft pith of the cane, as it came out from the different mills of a multiple-roller train, that rind bagasse from the first mill contained more fiber and less sucrose than pith bagasse; in the second mill the amount of sucrose left in pith

[33] Exp. Station Hawaiian Planters' Ass. Bull. No. 30 (1909).

and rind was about the same, although the rind still contained less sucrose per unit weight of fiber; while the third, fourth, and fifth mills yielded a much more completely exhausted pith bagasse without materially reducing the sucrose content of the rind. He concludes from this "that the milling process is very effective so far as regards the soft interior pith, but very crude as regards the excretion of sugar from the hard outer rind." This might indicate that canes possessing a soft fiber should allow of more efficient mill work than harder ones, provided more than six rollers are used. The opposite has been found true, however, by Geerligs[34] in Java, who says that "in most cases, canes having a high fiber content will yield bagasse the fiber of which offers but little resistance to pressure. This to some extent compensates for the increased loss of sugar occasioned by the large amount of bagasse obtained from canes of high fiber content. From the average of a great number of determinations it is seen that a high fiber content of the cane corresponds with a high fiber content of the bagasse, so that a hard cane yields a drier and more exhausted bagasse than a soft one." It is evident that there still is room for much work before this question can be solved.

Returning to Negros and the mill controls, it is seen that working with a poor juice, much less sucrose is lost in the skimmings than with a richer one, this because a lower density allows of more rapid and complete settling of impurities in the scum tanks, while volume for volume the skimmings from an inferior juice of course contain less sucrose. The loss by inversion, as far as could be detected by analysis, is about the same in each case; that caused by burning is enormously larger in the second experiment than in the first, and it is my belief that, in making "corriente" sugar from poor juice, much sugar is not only inverted and caramelized, but literally burned, some of it even forming gaseous products. The fumes from a very low-grade "massecuite" during the last portion of the boiling are sometimes so irritating as to be unbearable even to the native workmen.

The total losses in manufacture, referred to the sucrose in the cane, were not far different in each experiment, the poor cane losing only about 1 per cent more of its sucrose than the better one. As regards yield of raw sugar, this was somewhat less in the second test, but not so much as might be expected from the poorer quality of cane ground, since the loss in sucrose is largely compensated for by the larger amount of impurities turned out as "sugar." The yield of "corriente" sugar from this inferior cane was 0.942 tons per ton of cane, so that 10.61 tons of cane would be required to produce 1 ton of sugar.

Calculation of the average yield of raw sugar per ton of cane in Negros.—Combining the data brought out by all these experiments, the average losses of sucrose during the process of sugar making as carried on

[34] Cane Sugar and its Manufacture. Manchester (1909), 105.

in Negros are, expressed in percentages of total sucrose present in the cane, approximately as follows:

Loss—	On total sucrose in cane.
	Per cent.
In bagasse	25.0
In skimmings (where no filter press is used)	5.0
By inversion (including "apparent" or analytical losses)	2.5
Burned, spilled, stolen, and unaccounted for	10.0
"Shrinkage"[a] en route to Iloilo (including "tare")	1.5
Total	44.0

[a] This loss amounts to about 2.5 per cent of the total sugar produced. Since the sugar is, as a rule, not weighed accurately until it reaches Iloilo, and all estimations of the yield of an hacienda are based upon Iloilo weights, it is proper to include this loss in shipping with the other losses incident to manufacture and calculate it to per cent sucrose in cane.

Clean, ripe cane has already been shown by analysis to average as follows in four of the most important districts of Negros: Fiber, 10.02 per cent; sucrose, 16.06 per cent; with a juice, as expressed by moderately strong single crushing, of Brix, 20.35; sucrose, 18.40; purity, 90.38. In practice, the addition of about 2 per cent of cane trash has likewise been shown to increase the per cent of fiber in the cane as ground to 11.79 per cent, and reduce the sucrose to 15.75 per cent, so that the physical make-up of the cane would be fiber, 11.79 per cent; "juice" (of above composition), 85.57 per cent; "water other than juice," 2.64 per cent.

The juice from a large number of mills in Negros was found to average somewhat lower in sucrose and purity than that determined by analyses of small samples of cane, and it is very probable that, owing to carelessness in cutting and the introduction of more or less immature and dead cane into the mill, the juice of the cane actually ground would be represented more truly by the former figures than by the latter, so that the average cane of Negros as ground in the mill may be assumed to have approximately the following composition: Fiber, 11.79; juice (of the composition—Brix, 19.71; sucrose, 17.20 per cent; purity, 87.03 per cent; reducing sugar, 1.2 per cent), 85.57 per cent, corresponding to a total of sucrose in cane of 14.72 per cent.[35]

From the estimate of losses in manufacture just made it is seen that on an average 44 per cent of the total sucrose is lost in manufacture and 56 per cent recovered as raw sugar, so that the yield in sucrose per weight of cane would amount to 8.2 per cent, or, since the average

[35] Throughout this paper percentages have been generally expressed to two places of decimals, without, however, making any pretense at such extreme accuracy. Analytical work of this nature can usually be relied upon to about ± 0.2 per cent.

raw sugar made throughout the island contains 82 per cent sucrose, 1 ton of cane will yield almost exactly 0.1 ton of raw sugar.

This ratio of 10 to 1 will hold good with comparatively little variation throughout Negros, since, in the process of manufacture which is employed, the kind of cane ground affects the quality rather than the quantity of sugar produced. The extreme limits of variation may be set at approximately 11.5 per cent and 9 per cent, respectively, on the weight of the cane.

CALCULATION OF THE AVERAGE COST OF PRODUCING SUGAR IN NEGROS BY THE METHODS NOW EMPLOYED.

With the description of each step in the production of sugar in Negros, from the first cultivation of the soil to the marketing of the finished product in Iloilo, there has been included as careful an estimate as it was possible to secure of the average cost for labor in each operation, reducing the same to the unit bases of the picul [36] and the metric ton [37] of sugar produced; the picul because it is still the best known unit of weight among those locally interested in sugar production, and the metric ton as having the most widespread significance throughout the world in general. All prices are figured in Philippine currency.[38]

Summary of the cost of producing sugar in Negros, as calculated in the previous portion of this paper.

Item.	Cost per picul of sugar.	Cost per metric ton of sugar.
	Pesos.	*Pesos.*
Plowing, planting, and caring for the cane until it is ready to cut (from p. 88)	0.60	9.49
Cutting the cane (from p. 92)	.16	2.53
Carting the cane to the mill (from p. 92)	.16	2.53
Grinding the cane and manufacture of sugar (from p. 112)	.63	9.96
Cost at the hacienda (from p. 113)	1.55	24.51
Shipping to Iloilo and marketing there (from p. 114)	.53	8.38
Total	2.08	32.89

The above represents the bare cost of production and placing upon the market, and it is not surprising that those who stop at this point in their calculations should marvel at the fact that all Negros planters are not millionaires, when they can lay down sugar in Iloilo for about 2 pesos a picul.

A sugar plantation, however, like any other farm, represents a

[36] 1 picul equals 63.25 kilos, or 139.44 avoirdupois pounds.

[37] 1 metric ton equals 2,204.6 avoirdupois pounds, or 0.9842 "long" ton.

[38] 1 peso Philippine currency equals 50 cents United States currency.

considerable capital invested in land, animals, and equipment, and in addition to this requires no small outlay for special machinery, which, crude though it may be, becomes decidedly expensive by the time it has been brought to Iloilo, reshipped to Negros, and set up there on the hacienda. A sufficient working capital is also needed to pay advances to laborers, salaries and living expenses of the administrator and his assistants, and to keep the farm going until the sugar is sold. On all of this capital legitimate charges for interest and depreciation must be made and the total calculated to the amount of sugar made during the season before the true cost of production can be determined. This is a most difficult matter even roughly to approximate, and absolutely impossible at present to state with certainty, because of the enormous variations in the size, resources, and management of different haciendas. Unfortunately, those who are really well informed on this subject, as is the case in almost any other business, are as a rule the least anxious to give the general public the benefit of their knowledge. A fairly good idea of the fixed expenses on an ordinary sugar plantation may be obtained by assuming a typical hacienda of about average size and figuring out in detail the capital tied up in land, buildings, farm implements, machinery, work animals, etc., and adding to the depreciation and interest on this sum a certain amount for administration and household expenses. Such an ideal hacienda has already been assumed in connection with the calculation of the expenses for labor in the field. In that case it was found necessary to assume a plantation a little better cared for than the average, in order to obtain any reliable data, since the very poorest places, which reduce the general average of yield, have as a rule, no fixed system of cultivation which they follow, but expend a greater or less amount each year according as they may possess the capital or the credit to work with. For the same reason it is even more necessary in calculating fixed expenses to consider a place somewhere nearly adequately equipped for the work in hand, therefore the equipment and general expenses set forth in the following estimate will, per hectare of land, run somewhat higher than those of the average plantation in Negros at the present time. At the same time the estimated yield of 60 piculs (3.8 metric tons) of sugar per hectare of land is proportionally higher than the average of 42.9 piculs (2.7 metric tons) now secured, so that the amount of money expended will, when reduced to the unit of sugar made, not differ greatly in each case. This departure from strictly average conditions is an admitted defect in the calculation, but is justified by the much greater accuracy of information obtainable.

The hacienda about to be considered by no means represents the best equipment, or most efficient management, at present existing in Negros, but may be taken as a type of the average place not unduly

hampered by the lack of capital or credit. It may be added that this is a purely imaginary plantation and is not intended to describe any one place now in operation on the island.

Estimate of the cost for land, equipment, and maintenance of a sugar plantation in Negros containing 150 hectares of land, 50 of which are cultivated in new plant cane, 50 in ratoons, and the remainder left uncultivated, the annual production being assumed to be 6,000 piculs or 379.5 metric tons of raw sugar of an average polarization of 82°.

Item.	Cost in Philippine currency.
LAND.	*Pesos.*
150 hectares, at 100 pesos per hectare	15,000
EQUIPMENT.	
Boiler, engine, and sugar mill of 8 nominal horsepower, having a capacity of 80 piculs or 5 metric tons of sugar per day, landed and set up ready for operation in Negros	10,000
9 iron "cauas" or sugar kettles set up on the hacienda	900
Materials and labor used in constructing the bagasse furnace, the brick or stone work for the battery of "cauas," and the chimney	3,000
Materials and labor used in constructing the "camarin" or sugar house	2,000
Materials and labor used in constructing two bagasse sheds	1,500
Materials and labor used in constructing one dwelling house for manager and foreman	2,000
Materials and labor used in constructing 40 light-material houses for plantation laborers, at 40 pesos each	1,600
50 work animals (cf. p. 88), at 135 pesos each	6,750
20 carts for hauling cane and sugar, at 50 pesos each	1,000
1[a] kilometer portable tramway with 50 meters of curve sections and ten 1-ton cane cars, laid down on the hacienda	3,500
40 plows, at 20 pesos each	800
Other agricultural implements, such as harrows, hoes, bolos, etc	1,000
Advances to laborers[b]	3,000
Total	37,050
MAINTENANCE (AND RUNNING EXPENSES).	
Interest on the value of the land (15,000 pesos) at 10 per cent per annum	1,500
Interest (10 per cent) and depreciation (10 per cent) on the equipment (37,050 pesos)	7,410
Taxes (0.5 per cent of value of land and equipment)	260
Salary[c] of manager, at 100 pesos per month	1,200
Salary of 1 "dependiente" or European foreman, at 50 pesos per month	600
Wages of 2 "cabos" or native foremen, at 20 pesos per month each	480
Household expenses of manager and foreman, at 80 pesos per month	960
Total fixed expenses per annum	12,410

[a] This is hardly sufficient tramway for a plantation of this size, but as many have no tramway at all it was thought best to include only 1 kilometer here and make up the deficit with cane carts.

[b] Since a portion of this capital is invariably lost through laborers breaking their contracts and running away after securing advances, it is proper to include the amount advanced under "equipment" and subject it to depreciation as well as interest.

[c] The manager of an estate is generally paid a nominal salary and his living expenses, receiving every year a bonus of a certain percentage of the net profits for the season.

The above fixed charges, when calculated to the amount of sugar produced, result in an additional cost of 2.07 pesos per picul, or 32.72 pesos per metric ton, and the total cost, including everything, of producing sugar in Negros and marketing the same in Iloilo may be stated with some degree of accuracy to average 4.15 pesos per picul, or 65.61 pesos per metric ton.

Many planters undoubtedly turn out sugar at a much less cost, especially those located in the more fertile districts where it is not necessary to replant oftener than every three or four years, but there are many others who must plant afresh each year and consequently spend considerably more than the above figure. It should be remembered that these costs are supposed to include everything, with interest on the capital permanently invested at the rate of 10 per cent per year, the rate charged by the Agricultural Bank. In the case of the few planters using their own capital, if no interest is charged on this, the cost of production would be reduced to 3.28 pesos per picul or 51.86 pesos per metric ton.

POSSIBILITIES FOR IMPROVEMENT.

IN CULTIVATION.

The desirability of introducing a few other well-selected varieties of cane as a temporary or permanent substitute for the purple, in case of disease, has already been discussed. With a well-equipped experiment station, some work may be done toward raising seedling canes and possibly evolving new varieties still better adapted to local conditions. As regards cultural operations, it has been stated by those claiming to know that the Negros planter as a rule does not go deep enough in his first plowing, and should pay more attention to the harrow instead of the plow for subsequent operations. With an ordinary moldboard plow, and a carabao as the motive power, not much improvement in depth can be expected, although better results are said to have been obtained in some cases by use of the disc plow. The substitution of mules for carabaos has been suggested, but is hardly considered feasible at present owing to the high cost and uncertain mortality of the latter animals. Steam plowing engines are without doubt the most efficient method of caring for large estates, but their first cost puts them out of the reach of the small planter. Irrigation during a few months of the dry season would probably double the yield of cane in certain districts; others rarely suffer from drought, but much from excess of rain, especially where the soils are heavy clay. The latter would undoubtedly be benefited by subsoil drainage.

The question of the application of commercial fertilizers is, in my own opinion, one which can only definitely be settled by the practical results obtained by each planter on his own particular estate; fertiliza-

tion on a large scale might prove of great advantage on some soils, and yet result in pecuniary loss on others. All these problems, however, lie more within the province of the agriculturist than of the chemist. I am inclined to believe that the Negros planter has been rather undeservedly maligned in the past as regards his industry and capability. Considering the hardships he has had to contend with, the yield of cane he gets from his land is by no means as bad as might have been expected, and the increase in his available capital brought about by the present high price of sugar should alone greatly improve the condition of cane culture in the Island. However, as long as each individual planter is compelled to devote half his attention to the details of the manufacture of sugar, thereby neglecting his fields, the industry as a whole can never attain its maximum development.

IN MANUFACTURE.

This brings up the question of modernizing our methods of sugar making. It is a fact, undisputed by even the most ignorant on the subject, that three or more powerful mills in series will extract more juice from a given amount of cane than will the ordinary three-roller single mill, and that the sugar from this juice may be secured in a purer form and with less loss by the aid of vacuum pans and centrifugals than by open-pan boiling and crystallizing with a spade. Unfortunately, the necessary adjuncts to modern sugar fabrication are rather expensive articles, and not adapted to the use of small estates—even if they were, they would hardly yield happy results in the hands of the native sugar "maestro"—since to secure the most economical returns a modern mill should have a daily capacity of not much less than 500 tons of cane and should be kept driven at its full capacity without interruption during a grinding season of about one hundred days, which would necessitate a certain supply of 50,000 tons of cane. This amount would correspond to a total output per year under the present system of about 5,000 tons or 80,000 piculs of raw sugar, or about three times that of the largest estate on the island.

CENTRAL FACTORIES.

A sufficient quantity of cane to operate even a small-sized modern mill could only be supplied by combining the crops of a number of haciendas in the same immediate neighborhood so as to grind at one centrally located place, and since at the present day it is hardly possible to find in one district a group of planters possessed of sufficient capital and at the same time of sufficient confidence in one another harmoniously to operate a coöperative central factory, this would in all probability have to be erected and managed by outside capital. Now, the average sugar planter is a singularly practical individual, and probably would not be satisfied with the purely scientific pleasure of knowing that

his cane was, by improved methods, being turned into sugar of a much superior color and higher optical rotation, unless the benefit thereby resulting to him were made evident in terms of Philippine currency. The central factory, on the other hand, is not ordinarily conducted as a philanthropic enterprise, but represents a large amount of capital—often greater than the combined value of the farms from which it draws its supply of cane—on which dividends must be paid. To be satisfactory to all parties concerned, then, a change to modern methods of manufacture must not only yield the planter a greater profit than he is now receiving from his cane, but must likewise pay interest, depreciation, and dividends on an equal or larger investment represented by the central factory; in other words, from the same weight of cane just about double the amount of pesos must be extracted than are now being yielded by the process in use.

The methods of apportionment of the sugar produced vary in different countries, but as a rule the farmer receives from 45 to 55 per cent of the value of the sugar secured from his cane, according to local conditions and as to whether delivery is made at the central factory or on the hacienda. Taking 50 per cent as the average, without, however, assuming that this would necessarily be the most equitable ratio here, and leaving the prospective manufacturer as the most competent judge of what his share in the profits of such a transaction might be, it may be of interest to calculate approximately what would be the gain or loss to the planter if he should receive the value of half his cane only, manufactured into 96° centrifugal sugar, instead of the whole of it as 82° concrete as at present. It will be necessary to assume for such a calculation a fixed price for the two grades of sugar.

The price paid in the Iloilo market for Negros sugar has averaged during the first five months of this season, beginning November 1, 1909, about as follows:

Grade.	Price per picul.	Price per metric ton.
Superior:	*Pesos.*[a]	*Pesos.*
No. 1	7.50	118.59
No. 2	7.25	114.63
No. 3	7.00	110.68
Assorted	7.125	112.66
Wet	5.625	88.96
Current	4.00	63.24

[a] 1 peso per picul=0.3580 cents U. S. currency per pound avoirdupois.

In the New York market the price quoted for Iloilo "Assorted" is practically constant at 1 cent gold per pound less than that of 96° centrifugal. Therefore it would be logical to presume that at least the same difference in value would hold good in Iloilo, or, since a central factory of any size would be in a position to ship its sugar directly to New York at the same cost as if shipped from Iloilo,

the value of 96° centrifugal sugar at the factory in Negros may safely be assumed to be, under normal market conditions, 1 cent gold per pound, or 2.789 pesos per picul, or 44.09 pesos per metric ton greater than that of "Assorted" at Iloilo at any given time. With Iloilo prices as quoted above, 96° centrifugal would be worth at the factory in Negros 9.914 pesos per picul, or 156.75 pesos per metric ton (3.56 cents gold per avoirdupois pound).[39]

As a basis of comparison of profits by each system may be used the hacienda of 150 hectares just discussed, which produces annually 6,000 piculs (379.5 metric tons) of sugar of 82° polarization from ten times this weight of cane. Given the composition of the cane as ground (see p. 122), it is a comparatively simple matter to calculate the approximate yield of 96° crystals obtainable by the average modern sugar factory from the same weight of cane. A fairly good mill, consisting of, say, nine rollers, with a preliminary crusher, will lose in the bagasse the equivalent of about 60 parts first mill juice for every 100 parts of fiber present (this is about the average ratio of over 100 estates in Java, as calculated from data given by Geerligs,[40]) and, since the cane as ground in Negros contains 11.79 per cent fiber, the juice lost would amount to 7.07 per cent of the weight of the cane, and there would, therefore, be extracted 85.57—7.07=78.50 per cent of the weight of the cane as juice. The average mill juice in Negros was found to contain 17.20 per cent sucrose, so there would be extracted 13.50 per cent sucrose on the weight of the cane, or 91.70 per cent of the total sucrose. The quotient of purity of the mixed juice would, with this increased extraction, drop about 2 per cent, or to 85. Substituting this figure in the commonly used formula of "available commercial sugar=per cent sucrose extracted in juice$\times\left(1.4-\frac{40}{\text{purity of juice}}\right)$" we find that 92.9 per cent of the sucrose extracted should be recovered as commercial 96° sugar, making a yield of 12.5 per cent sugar on the weight of the cane. From 60,000 piculs (3,795 metric tons) we should expect to get by fairly good working 7,500 piculs (474.4 metric tons) of 96° crystals, half of which or 3,750 piculs (237.2 metric tons), we are assuming, goes to the planter. His cost of production under the new system would be the same as by the old, less 1.16 pesos per picul (18.34 pesos per metric ton) for manufacture and marketing in Iloilo (see pp. 114 and 123), which would make the figure 2.99 pesos per picul (47.27 pesos per metric ton).

The profits of this plantation under the present and under the new system could be estimated as follows:

Present system.

	Pesos
Received from the sale of—	
6,000 piculs / 379.5 metric tons of 82° sugar, No. 3, at 7 pesos per picul / 110 pesos per metric ton	42,000
Cost of production of the same, at 4.15 pesos per picul / 65.61 pesos per metric ton	24,900
Profit	17,100

[39] At the time of writing (March, 1910) all prices are very much higher than at the beginning of the season, so that the season's average will probably be considerably higher than these figures quoted above. This does not affect the calculation materially, as the *difference* in price between 96° and assorted remains unchanged.

[40] *Internat. Sugar Journ.* (1909), 11, 324.

Central factory system.

Received from the sale of—	
3,750 piculs / 237.2 metric tons of 96° sugar, at 9.914 pesos per picul / 156.75 pesos per metric ton	37,178
Cost of growing—	
60,000 piculs / 3,795 metric tons of cane, at 2.99 pesos per picul / 47.27 pesos per metric ton	17,940
Profit	19,238
Increase of profit by new, over old system	2,138

According to these figures, the planter whose sugar averages "No. 3" in quality could, by selling his cane on the estate for half its value in 96° crystals instead of manufacturing it himself, make an increased profit of about 36 centavos for each picul of sugar which he now produces. Calculated to the metric ton of sugar, this increased gain would amount to 5.64 pesos, or about 56 centavos on each ton of cane now grown.

In the case of an estate producing exclusively No. 1 sugar, the gain by selling this very rich cane instead of manufacturing it would not be so large, although an increased profit would still result.

Assuming that the cane grown by the above hacienda were all of the same quality as that ground in Mill Control No. 1 (p. 116), and that it were manufactured in exactly the same manner, except that No. 1 sugar, as it should have been, were produced, the yield of sugar would be 11.15 per cent, hacienda weight, or, deducting for "shrinkage," 10.87 per cent, Iloilo weight, expressed in per cent on the weight of the cane. To make 6,000 piculs (379.5 metric tons) of sugar would require 55,188 piculs (3,490.6 metric tons) of cane. From the composition of this cane (see p. 116) we find that a fairly good modern mill, by the same calculation as that made previously, would lose in the bagasse 8.78 parts juice and 1.85 per cent sucrose on the cane, and would extract in the juice 15.2 per cent sucrose on the weight of the cane. The purity of the juice would drop about 2 per cent again, or to 89, and the factor $1.4-\frac{40}{\text{purity}}$ would in this case be 95.1 and there should be yielded, in the form of 96° sugar, 14.45 per cent of the weight of the cane, so that 7,974 piculs (504.4 metric tons) would be produced from the above weight of cane.

The profits under each system would then be:

Present system.

	Pesos.
Received from the sale of—	
6,000 piculs / 379.5 metric tons of sugar, No. 1, at 7.50 pesos per picul / 118.59 pesos per metric ton	45,000
Cost of production,[41] as in the previous account	24,900
Profit	20,000

[41] For lack of more exact information on this point, the cost of production of all grades of sugar is taken to be the same. Although somewhat less cane is required to produce a superior than an inferior sugar, the poorer cane generally grows larger and yields a heavier tonnage per hectare, so that the cost of growing cane equivalent to a given weight of sugar is much the same, whatever the quality.

Central factory system.

Received from the sale of—	
3,987 piculs / 252.2 metric tons } of 96° sugar, at { 9.914 pesos per picul / 156.75 pesos per metric ton }	39,527
Cost of growing cane, as before	17,940
Profit	21,587
Increase profit due to factory system	1,487

By changing to the modern system, the estate making nothing but No. 1 sugar would still gain 0.25 pesos per picul (3.93 pesos per metric ton) of sugar or 43 centavos per metric ton of cane now produced.

One of the greatest disadvantages of the system of sugar making still used in Negros is its entire dependence upon the quality of the cane ground for producing a fairly good sugar. There is scarcely a plantation on the island which does not, during the course of the year, turn out a certain amount of low-grade sugar at practically no profit; especially is this the case with those located on new and very rich lands, where the cane grows luxuriantly, but is of rather poorer quality. A large factory, equipped with vacuum pans and centrifugals, is of course able to produce an unvaryingly good quality of sugar from almost any kind of cane, inferiority in the latter simply resulting in a diminished yield.

To illustrate this difference specifically, we can assume that the estate just discussed, through some misfortune, manufactures its entire output of 6,000 piculs as the lowest grade of current sugar. Of course, this would not occur in practice, or the estate would soon go into bankruptcy, but the relative difference in profit from this class of cane will be the same, whatever the percentage of it produced. In Mill Control No. 2 (p. 118) 1 ton of current sugar was produced from 10.61 tons of cane, or, if the sugar is weighed at Iloilo, from 10.89 tons of cane; therefore to produce 6,000 piculs (379.5 metric tons) of concrete sugar from this kind of cane, 65,340 piculs (4,131.7 metric tons) of cane are required. A fairly good modern mill working this cane would lose in bagasse 6.31 per cent juice and 0.87 per cent sucrose, and hence would extract in juice $11.66-0.87=10.79$ per cent sucrose on the weight of the cane. The purity of the juice could be expected to fall to 75.9, making the empirical factor of availability $1.4-\frac{40}{\text{purity}}=87.3$, and as the available 96° sugar in this cane might be considered as 9.42 per cent; 6,154 piculs (389.2 metric tons) of 96° sugar could be made from it.

The profit and loss accounts would be as follows:

Present system.

	Pesos.
Received from the sale of—	
6,000 piculs / 379.5 metric tons } of "current" sugar, at { 4 pesos per picul / 63.24 pesos per metric ton }	24,000
Cost of production, as in previous account	24,900
Loss	900

Central factory system.

Received from the sale of—	
3,077 piculs / 194.6 metric tons of 96° sugar, at 9.914 pesos per picul / 156.75 pesos per metric ton	30,505
Cost of growing the cane, as before	17,940
Profit	12,565
Increased profit due to factory system	13,465

From this it is evident that from every ton of inferior cane which is now made into "current" sugar at a loss of 22 centavos a metric ton of cane, 2.37 pesos a ton of sugar, or 15 centavos a picul of sugar, there could, by the central factory system, be realized a *profit* to the planter of 3.04 pesos per ton of cane, 33.10 pesos per ton of sugar (figured on the yield now secured), or 2.09 pesos per picul of sugar.

ADVANTAGES OF A CHANGE TO MODERN METHODS OF MANUFACTURE.

It has been shown by the preceding figures that the average planter of Negros should be able to secure considerably more profit from his cane if he could sell it on the plantation for half its value in 96° sugar instead of grinding it himself as at present, the difference in profit being much more marked in the case of a poor quality of cane than with a richer one. In all these calculations, the cost of producing cane has been taken as the total cost of production of sugar by the present method minus the present cost of manufacture and sale of the raw sugar, thus including interest and depreciation on the manufacturing plant now in use. This extra charge against growing the cane, while proper at the present time, since the small mills are already in existence and represent capital invested, would under the central factory system become less each year, since there would be no necessity for the upkeep of individual milling plants, and would be eventually written off, so that the difference in gain, as in the case of a new plantation equipped solely for producing cane, would then be much greater. However, the farmer should not at the start expect too large an actual money profit from a change to the central factory system, for the reason previously stated that, although an increased yield, both in quantity and quality of sugar, would result therefrom, yet the same amount of cane would be forced to pay dividends on much more capital than is now invested. By far the greatest benefit to the farmer which would result from this system would be its freeing him from the cares and troubles of manufacturing his own sugar, thus allowing him to devote all his energy toward the proper cultivation of his fields. This factor is so important that it alone would warrant a change to modern methods; and, even if the profit from a given weight of cane were somewhat less, the greater amount of land which could be put under intelligent cultivation would more than pay for the change. Contrary to the ideas of some, the labor question would be rather improved than

otherwise by such a change. As it is now, ten individual mills of a capacity of 50 tons of cane each require in all from 500 to 700 laborers in the mill house and for sun drying the bagasse, while a modern sugar factory of a capacity of 500 tons of cane per day could do with at least a fifth this number of unskilled laborers, thus leaving a still larger number available for field work. The present low cost of labor in Negros can not be expected to continue indefinitely; the laboring classes of the natives are gradually becoming educated to a higher standard of living, and with this must necessarily follow a higher wage rate, so that the advantages of centralization and mechanical economy of labor must, with time, become more and more apparent.

THE FUTURE OF NEGROS.

Predictions and calculations as to the possibilities of sugar-producing countries are notoriously inexact. In the case of Negros much depends upon the first attempt at the introduction of outside capital and modern methods of milling. A successfully operated central factory in any one of the seven different districts, even if run on a comparatively small scale, would demonstrate its own advantages to the planter more practically than could any amount of papers such as the present one, while if, through mismanagement or lack of tact in dealing with the cane growers, the first factory installed should result unsatisfactorily, the progress of the country would probably be set back many years. Under the present system of production, even with sugar at a high price and more capital at the disposal of the planter, the total annual production of the island can hardly hope to more than treble itself in the next fifteen years, this on the assumption that two-thirds, instead of as at present one-third of all the known available sugar land were to be cultivated, and that the average yield of sugar per hectare could be raised 50 per cent, or to about 4 metric tons, thus yielding in all some 220,000 metric tons of sugar. The advent of more rational methods of sugar manufacture would not in itself, as has been previously shown in detail, cause a greatly increased yield of sugar from the same weight of cane, but its stimulating effect on the industry in general would certainly be very great. It may be estimated conservatively that an extent of land equal to the total of that now known as good sugar soil, or something over 80,000 hectares, could, given the necessary incentive in the way of an increased value and a ready sale for the cane grown, be cultivated in sugar cane annually; while it is, of course, true that not all the land now reported as fit for sugar culture is, or ever can be, cultivated each year successively without giving it a rest during a part of the time by allowing it to lie fallow, or by growing temporarily some other crop, yet there is still considerable virgin forest land as yet undeveloped—in the extreme

southern portion of Occidental Negros, for instance—while, as has been brought out in dealing with the individual districts in a previous part of this paper, a good deal of low land now considered fit only for rice culture could be made available for sugar cane by expending a little money on drainage. It is, moreover, not unreasonable to suppose that the average yield of sugar per hectare, once cane growing were freed from its dependence upon the caprices of manufacture on a small scale and the planter left free to attend to this branch of the industry alone, could, at only a moderately increased expense for fertilizers and irrigation where needed, be raised from the present low figure of 2.71 metric tons (42.9 piculs) to more than double this amount, or, say, 6 metric tons (95 piculs) of sugar per hectare. The possible yield of sugar from Negros under the most favorable conditions would thus be nearly seven times the present one. The probable limits of annual sugar production in Negros during the next fifteen years might, therefore, be estimated at a venture to be about 220,000 metric tons under the present system of small individual mills and estates, and 500,000 metric tons with adequate capital, careful cultivation, and a complete change to modern methods of manufacture. Just which of these limits will be more nearly approached can not be foretold, since it depends almost entirely upon the extent to which new methods shall be substituted for old.

SUMMARY.

A brief description of the Island of Negros is given, together with general information regarding its geographical location, size, shape and area, mountains, rivers, meteorologic conditions, history of its sugar production, varieties of cane grown, nationality of the planters, and the labor available.

Statistics compiled by the Bureau of Internal Revenue for the year 1908 show that at that time there were in the entire island 484 sugar planters, who controlled a total of 65,641 hectares of land, of which 27,096 were under cultivation and 38,545 unplanted. In addition, 16,904 hectares were certified to as being suitable for cane growing, but not at that time so used, making a total of 82,545 hectares of available sugar land in Negros. In that year 73,494 metric tons of raw sugar were produced, or an average of 2.71 metric tons per hectare of land planted. The low average is caused largely by lack of capital and by inefficient cultivation on the part of many of the small growers. The average yield on a well-cared-for plantation should amount to about 4 metric tons per hectare.

Very little damage has ever been reported as having been caused by cane diseases or insects. These subjects are now being taken up as a special investigation by the Bureau of Science.

The Island of Negros may be divided into seven important sugar dis-

tricts, each producing 5,000 tons or more annually, four of these, Silay (comprising the municipalities of Victorias, Saravia, Silay, and Talisay), Bago, Pontevedra-La Carlota, Binalbagan-Isabela and Ilog-Cabancalan, being on the west, and two, San Carlos and Bais, on the east coast. Each of these districts is described separately, representative analyses of soils and sugar cane grown thereon being also given. Silay was found to lead in point of total annual production, although the quality of its soil and the yield per hectare are decidedly inferior to most other parts of the island. The largest production per hectare was found in Ilog-Cabancalan, which averaged 4.45 metric tons, Pontevedra-La Carlota being second with 4.39 metric tons.

The average composition of the soils from all the districts examined is:

Surface soil: Fine earth, 97.39 per cent; potash, 0.20 per cent; soda, 0.18 per cent; lime, 1.66 per cent; magnesia, 0.98 per cent; phosphoric acid, 0.15 per cent; nitrogen, 0.14 per cent; "volatile matter," 9.31 per cent.

Subsoil: Fine earth, 96.10 per cent; potash, 0.17 per cent; soda, 0.17 per cent; lime, 1.79 per cent; magnesia, 0.99 per cent; phosphoric acid, 0.12 per cent; nitrogen, 0.10 per cent; volatile matter, 9.19 per cent.

The Negros soil as a whole may be considered as being decidedly high in lime, but only moderately so in the other constituents of plant food. Compared with sugar soils from other countries, those of Negros, while not exceptionally rich, are fully up to the average, and under proper cultivation should produce as much sugar as those of almost any other country having the same climatic conditions.

Very little attention is paid in Negros to fertilization of any kind. In the case of commercial fertilizers this is perhaps justified by their high price and lack of instruction as to their proper application, but much improvement in crop yields could be brought about at comparatively little expense by a more common utilization of the materials available on every estate, such as bagasse ash, sugar-house refuse, animal manure, and green manuring by planting occasional leguminous crops.

The average composition of clean, ripe cane of the purple or native variety commonly grown in Negros was found in four of the most important districts to be as follows: In the whole cane—average weight 0.92 kilo, sucrose 16.06 per cent, fiber 10.02 per cent; in the juice—Brix 20.35, sucrose 18.40, purity 90.38, reducing sugar 0.71. In comparison with canes from other countries, that of Negros is distinguished by its extreme sweetness and purity and relatively small amount of fiber, factors tending toward an easy and thorough extraction by milling. The percentage of fiber in this cane is in actual practice about 2 per cent higher because of trash ground with the cane.

Although a marked improvement on the native cane in respect to

sucrose content and free-milling qualities is hardly to be expected, it is recommended that a few other good varieties of cane be introduced into Negros and grown somewhat extensively, so as to have a reserve to fall back on for seed in case the present variety should ever be attacked by disease of any kind. Experience in other countries has proved that it is a dangerous policy to rely entirely upon one variety of cane. Some black cane is now being grown in Negros, and this, because of its rather high fiber content and habit of growing erect, should prove desirable as a substitute for the purple cane in certain very rich or sandy soils, where the latter has a tendency to fall down badly and not mature.

Cultural operations are much the same in Negros as in other countries. After burning a field and plowing it, the seed is laid out in rows, about 25,000 being planted to the hectare. Only the cane tops are used for planting. Planting is carried on at the same time as cutting and grinding, usually between the months of November and May, and the cane remains in the ground to ripen for from ten to fourteen months. The carabao is the only work animal at present used. Ratoon canes are extensively grown in Binalbagan-Isabela, Ilog-Cabancalan, San Carlos, and Bais; in the majority of other parts of the island they are the exception rather than the rule. Approximately one-half of each year's crop throughout the island may be said to come from plant cane. Cane is cut and loaded by hand, and carried to the mill in bull carts or by means of light, portable tramways.

The mills of Negros are of the single, three-roller type, nearly all run by steam, and having an average capacity of about 50 to 60 metric tons of cane per day of twelve to fourteen hours. Bagasse is used for fuel, but is not crushed dry enough to be burned directly, so it must be given a preliminary drying in the sun, which entails considerable extra expense and renders the planter dependent on fair weather for running his mill.

From tests made from a large number of mills in different parts of Negros, it is calculated that from 20 to 35 per cent of the total sucrose of the cane is lost in the bagasse, depending upon the amount of fiber in the cane. The average loss is 25 per cent, giving a juice extraction of 64.5 per cent on the weight of the cane, a figure somewhat better than might be expected, due not to any superior efficiency of the mills, but rather to the small amount of fiber in the cane usually ground.

The juice is boiled down in a train of open, hemispherical, iron kettles set over a direct fire. It is defecated with lime, and a fairly good clarification is effected in the first four of these kettles by skimming impurities off from the surface. The sirup, after clarification and concentration to about 50° Brix is boiled down in the final kettle to a

"massecuite" of from 5 to 10 per cent water content, then poured out into shallow trays and stirred with a spade until it crystallizes. No attempt is made to separate sugar and molasses, but the whole "concrete" is sacked and sold as such.

The losses of sucrose in open-kettle boiling occur chiefly in the final boiling of "massecuite," where a large amount of sugar may be caramelized and even burned by local overheating and sticking to the sides of the kettle. Where filter presses are not used, a great deal of sugar is also thrown away in the skimmings. Very little loss by inversion occurs in the preliminary clarification and concentration to 50° Brix in the first four kettles, provided only moderate care is taken in liming to approximate neutrality.

Heretofore it has been impossible to secure reliable data as to the amount of sugar produced in Negros from a given weight of cane, since the cane itself is never weighed, and the sugar, as a rule, only after it reaches Iloilo and is sold. After considerable difficulty it was found possible to make two complete mill controls of cane of widely different composition, and from a combination of the data thus obtained and comparative analyses of juices and sugars from a large number of mills throughout the island the average in sucrose ordinarily produced is calculated to be approximately the following:

Loss—	Sucrose in cane.
	Per cent.
In bagasse	25.0
In skimmings	5.0
By inversion	2.5
Burned, spilled, stolen, and unaccounted for	10.0
"Shrinkage" en route to Iloilo before weighing	1.5
Total	44.0

The cane as ordinarily ground in the mills averages 14.72 per cent sucrose, so the yield in sucrose on the weight of the cane amounts to 8.24 per cent, or almost exactly 10 per cent of raw sugar polarizing 82°, the average polarization of Negros sugar.

Negros sugar is practically all sold in Iloilo, where it is classified as "Superior" Nos. 1, 2, and 3, "Wet," and "Current," of polarization minima of 87°, 85°, 80°, 76°, and 70°, respectively. The difference in market price has heretofore been arbitrarily fixed at 25 centavos between grades of "Superior." The two lower grades have usually been shipped to China, and bear no fixed price relation to the "Superior" sugars.

The average cost of producing sugar by the present process in Negros is estimated as approximately the following:

	Cost per picul of sugar.	Cost per metric ton of sugar.
Plowing, planting, and caring for the cane until it is ready to cut	*Pesos.* 0.60	*Pesos.* 9.49
Cutting the cane	.16	2.53
Carting cane to the mill	.16	2.53
Grinding the cane and manufacture of sugar	.63	9.96
Shipping to Iloilo and marketing there	.53	8.38
Total fixed expenses, including 10 per cent depreciation and 10 per cent interest on the capital invested	2.07	32.72
Total	4.15	65.61

A few possibilities for improvement are suggested, the chief among them being the substitution of modern methods of manufacture. It is shown that the average planter could by selling his cane to a central factory earn a somewhat larger profit from it than by manufacturing it into sugar himself under the present method, the difference in profit being much more marked with inferior than with very rich and pure cane. The greatest benefit to the planter under the modern system would result from his being thereby rendered independent of manufacturing details and largely of weather conditions, so that he would be enabled to operate on a much smaller working capital and at the same time secure better results from his land.

The annual limits of sugar production in Negros during the next fifteen years may be estimated at about 220,000 metric tons of low-grade sugar under the present system of manufacture or 500,000 metric tons of 96° centrifugal sugar if a complete change should be made to modern methods of manufacture. The larger production under the modern system would be due not so much to a greatly increased yield as to the stimulus to the industry in general and consequent improvement in cultural methods which would follow in its train.

APPENDIX.

AN INVESTIGATION TO DISCOVER IF DISEASES OF THE SUGAR CANE EXIST IN NEGROS.

By Elmer D. Merrill, *Botanist*, and Charles S. Banks, *Entomologist*, *Bureau of Science, Manila, P. I.*

FUNGUS AND OTHER DISEASES.

Philippine sugar cane appears, after a preliminary investigation, to be rather remarkably free from disease. There are unquestionably certain fungi, parasitic on the sugar cane, present in the Philippines, but it appears to be rare that any of these become sufficiently abundant to injure the cane in any noticeable degree.

The only serious disease that has come to our notice was an outbreak of the sugar cane smut, caused by the fungus *Ustilago sacchari*, in Laguna Province, Luzon, in the year 1908. This outbreak was investigated by Dr. C. B. Robinson, of this Bureau, and although the fungus was found to be abundant in certain fields, and quite fatal to the young plants, it was very local in extent and quickly disappeared under proper cultural treatment. Doctor Robinson's report on this case will be found in the Philippine Agricultural Review.[1]

In the early part of the present year a verbal report was received at the Bureau of Science to the effect that the sugar cane throughout Negros, and, in fact, in other parts of the Philippines, was badly infected with "red rot," caused by the fungus *Collelotrichum falcatum*. It was stated that this disease was so common in the Archipelago that it would be unwise to use Philippine sugar cane for seed in establishing new plantations on account of the danger of infection. "Red rot," although not exceedingly difficult to control, has, in some countries, caused much damage to the cane fields, so that, considering the nature of the report and the reputed seriousness of the attack, it was deemed expedient to investigate at once. In May, 1910, the sugar-cane districts about Cabancalan, Negros, and Bago, Negros, were visited, but a careful search in a number of different fields failed to reveal a single specimen of sugar cane infected with the fungus, nor were any of the canes examined found to suffer from other diseases that might be mistaken for the above malady. No traces of "red rot" have been found on sugar cane in the vicinity of Manila, and Dr. E. B. Copeland, dean of the College of Agriculture at Los Baños, informs us that he has been unable so far to find it in Laguna Province.

While searching for the "red rot" of the sugar cane in Negros, advantage was taken of the opportunity to collect specimens of all other fungi parasitic on the

[1] *Phil. Agric. Rev.* (1908), 1, 295–297.

cane. Two or three different species were found, including probably *Cercospora sacchari*, causing the so-called "eye spot disease" of the sugar-cane leaf, which is of very minor importance. The remaining species are at present unidentified, but it is confidently assumed that none of them are of a decidedly injurious nature. Parasitic fungi are very rare in Negros—it was only occasionally that a plant could be found that was infected by any fungus—and in no case was a plant found to be badly infected.

"Root rot," caused by various fleshy fungi, "red-rot," as noted above, "rind disease," "top rot," or any other fungous or bacterial disease of a serious nature was not observed by us in Negros. The matter was discussed with several planters, and none of them could recall ever having seen any of the maladies in question. The latter statement is, of course, of rather doubtful value in determining whether or not various diseases are or have been present, as an untrained person might easily overlook them, or fail to credit minor injuries to his sugar cane to the proper causes. While it is not claimed that some or all of the diseases mentioned above are not present in the Philippines, it is maintained that if they are present, they are of such rare occurrence, that the damage being done by them in the Philippines at the present time is a negligible quantity.

INSECTS.

As some attention had been given to the question of sugar-cane insects in Negros about eight years ago, and as at that time few serious pests were encountered, it was surmised that the reports this year might be exaggerated and that there was no greater abundance of insects than usual.

A careful investigation was made, therefore, over a territory of some 10 square kilometers in the region of Cabancalan on the Ilog River and about 2 square kilometers at Bago farther north. Inquiries among the farmers brought out the fact that for forty or more years sugar has been raised annually upon the same plots of ground without recourse to fertilizers or rotation of crops, or even a change of seed plants more than from one hacienda to another in the same locality.

Naturally any insects that might have a special predilection for sugar cane would go on increasing slowly from year to year under a condition of practically absolute immunity, excepting the possible attacks of natural parasites.

The attacks of insects upon sugar cane, at the present time, can not be said to be serious, except that in so far as they remain unchecked they go on increasing, and it is probably only a matter of a certain number of years when it will be impossible to raise sugar cane on those lands where farmers, instead of trying to plow and cultivate as many times as possible in a season, seem to wish to do this as few times as they can and never pay attention to rotation of crops or resting the land.

THE CANE ROOT BEETLE.

(*Holotrichia vidua* Sharp) [*Melolonthidæ*.]

This beetle is probably the most serious pest in the sugar-cane region visited. The larvæ, pupæ, and full-grown beetles were found in numbers in the ground around the roots of first and second year *calaanan*,[2] or ratoons. From a single

[2] Calaanan is a Visayan term used to designate cane which springs up after the crop has been cut off a field. In the region visited as many as eight crops have been harvested without a replanting of cane seed, or "*puntas*," as they are called locally.

hill in a field from which the cane had been cut two months previously, fourteen adults, three pupæ, and seven larvæ were taken.

Little or nothing is known of the length of larval life of this particular species, but, based upon a knowledge of related insects, the assertion can safely be made that deep and repeated plowing and other vigorous cultural methods accompanied by allowing the land to rest for one or two years and the planting of other crops would be the only means of successfully combating this insect.

THE CANE TIP BORER.

(*? Scirpophaga intacta* Sn.) [*Pyralidæ.*]

The young cane, three to four months old, over certain large areas was badly attacked by a tip borer resembling, in the appearance of the larva and the character of its work, the species described by Van Derventer [3] as damaging sugar cane in Java.

It is claimed by the farmers in Negros that this insect, rather than being injurious, serves as a pruning agent, thereby reducing the excessive number of ratoons springing from a single hill, and thus saving them the labor of cutting out the excess of plants.

It would seem that this is a very poor means of accomplishing such a result, especially as cases have been seen where all the plants in many rows 8 to 10 meters long were affected. Moreover, the energy expended by the plant in sending up these excessive ratoons, later to be destroyed by insects, might have been utilized in the production of fewer and more robust ratoons, less subject to insect attacks.

As there was no time to investigate the whole life history of this insect when I visited these plantations, it is impossible to state the best season for cutting and destroying plants known to be attacked. It is very easy to distinguish them in a given field, as their top and center leaves are invariably dead and of a pale yellow hue.

THE WHITE LEAF LOUSE.

(*Oregma lanigera* Zehnt.) [*Aphidæ.*]

This insect was found in great abundance on a single hacienda near the town of Cabancalan, one field of about four months' old cane being very badly infested. There is no doubt but that the serious degree of infestation was due to the excessive crowding of the plants and the absolute lack of any cultivation since the old crop had been cut off.

It was very evident that the only remedy for this condition of things was to burn off the infested cane and either replant after proper preparation of the ground or trust to a resprouting from the old stands. Both of these methods were suggested to the owner, but he seemed quite unwilling to take the responsibility, as the cane was bing worked on shares with another man.

The size of the field and the dense growth of the cane would have precluded any attempt at spraying such as is recommended by Van Deventer,[4] even if the farmers in this part of the world were familiar with the use of sprays and spraying apparatus.

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[3] Handboek ten dienste van de Suikerriet-Culture en de Rietsuiker-fabricage of Java. Tweede Deel, de Dierlijke Vijanden van het Suikerriet (1906), 114.

[4] *Loc. cit.* 187 and 196.

THE CANE FULGORID.

(*Phenice moesta* Westw.) [*Fulgoridæ.*]

While no other insects were found attacking cane in Negros, there is another which may prove of interest should it increase in parts of Luzon where it has been observed.

This small, black and white insect has been met with frequently in Manila and vicinity, resting in large numbers on the undersides of cane leaves and sucking their juices.

It has been reported as damaging certain palms in Assam and as attacking leaves of sycamore in Java, but I believe no mention has hitherto been made of danger to sugar cane from its attack.

While these investigations of sugar insects showed a condition of rather general and widespread infestation, they indicate a serious present menace in but one or two places. However, they mean that the farmer can not longer depend upon unassisted nature in his cultivation of cane.

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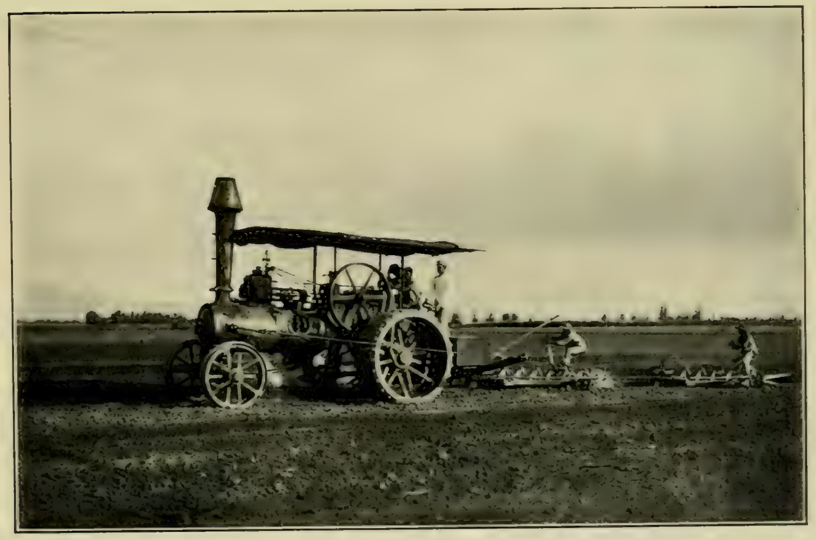

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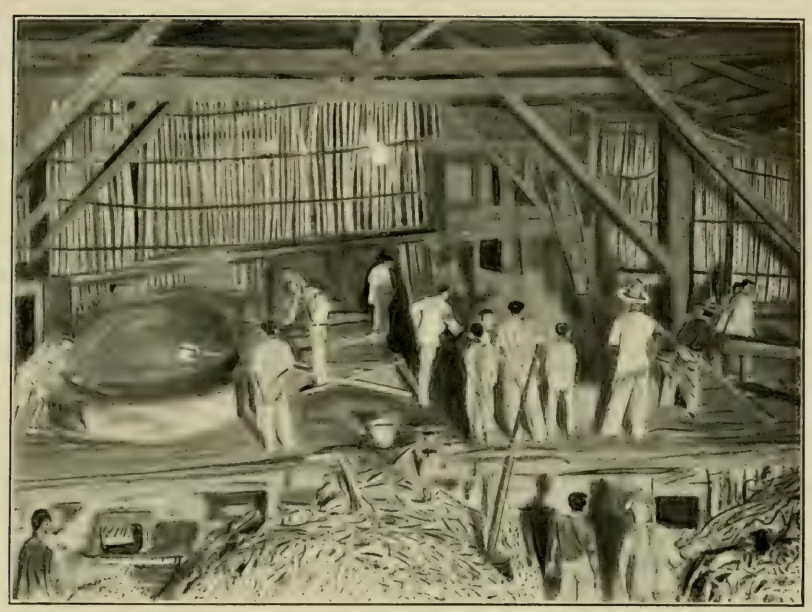

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